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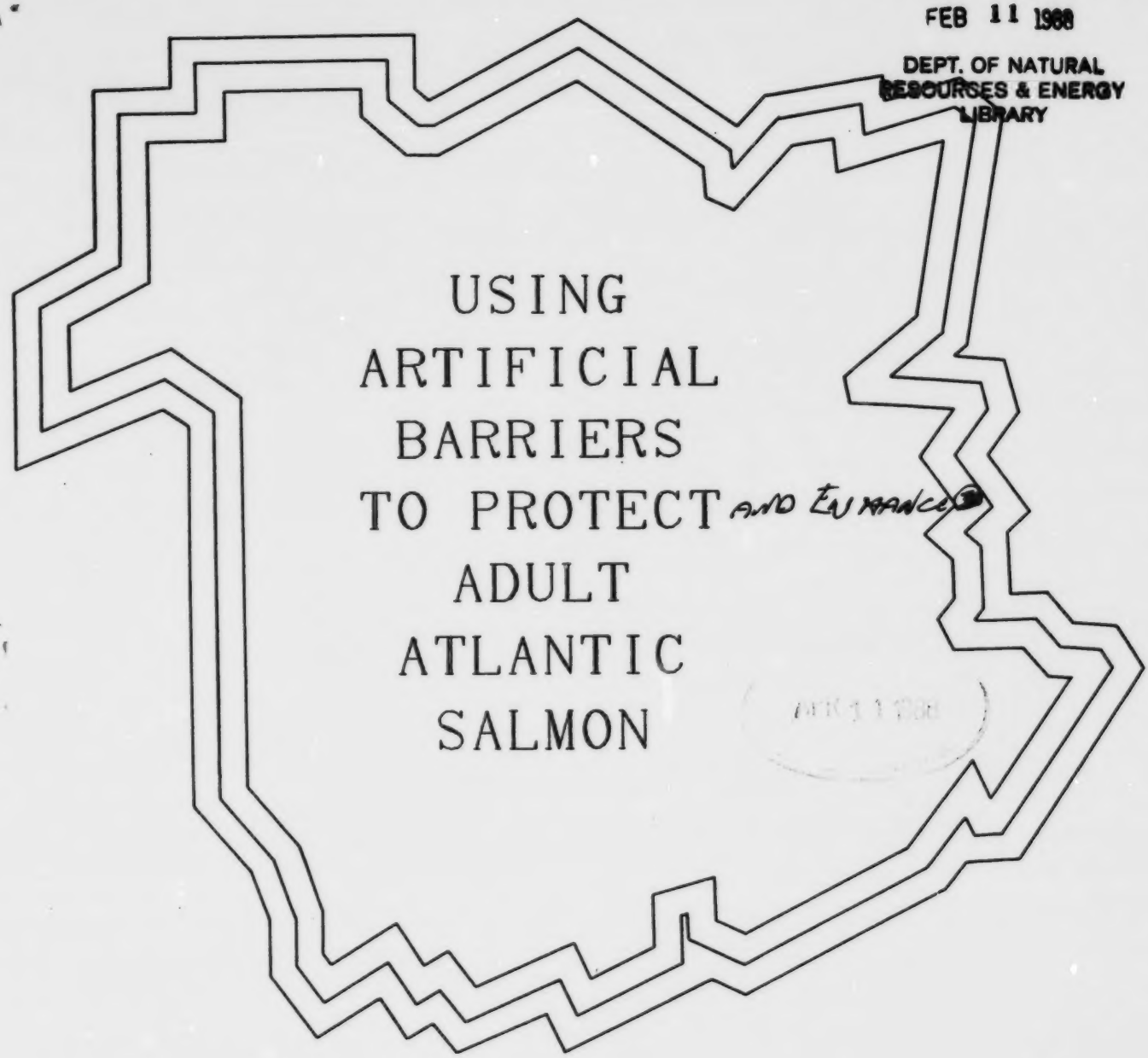

USING ARTIFICIAL BARRIERS TO PROTECT AND ENHANCE ADULT ATLANTIC SALMON

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USING ARTIFICIAL BARRIERS TO PROTECT ADULT ATLANTIC SALMON

FINAL DRAFT

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Department of Natural Resources & Energy

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ABSTRACT

An Atlantic salmon (Salmo salar) enhancement strategy was developed and implemented on three river systems in New Brunswick. The strategy was to (1) concentrate the upstream migrating adult salmon in one major holding pool by means of an artificial barrier placed at the head of the pool, (2) concentrate the enforcement at that site and (3) release the salmon just prior to the spawning period. The objectives were to (1) increase spawning escapement, (2) evaluate an alternate protection method and (3) determine whether the salmon used traditional spawning grounds upstream from the site. The barrier pool strategy has proven to be an effective and practical enforcement technique contributing to increased spawning escapement of Atlantic salmon on the Northwest Upsalquitch in the Restigouche watershed and the Dungarvon and North Branch of the Main Southwest Miramichi rivers in the Miramichi drainage. The number of large salmon and grilse counted annually, from 1979 to 1986, at the barriers on the Upsalquitch, Dungarvon and North Branch ranged from 731 to 2905, from 408 to 698 and from 509 to 3210, respectively, with the highest counts being attained on the Upsalquitch and North Branch

in 1986 and the Dungarvon in 1985. The percentages of Atlantic salmon that survived to spawn over the duration of the projects averaged 80.0, 99.3 and 99.7% on the Upsalquitch, Dungarvon and North Branch rivers, respectively. Traditional spawning grounds continued to be used based on distribution of redds and juvenile salmon.

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INTRODUCTION

Several rivers in northern and central New Brunswick and on the Gaspe Peninsula, Quebec produce early sea-run Atlantic salmon (Salmo salar). The fish enter these rivers in late spring-early summer, quickly ascend to headwaters and congregate in pools in proximity to spawning grounds. Such pools are usually smaller than those in the lower reaches of the river and are referred to as holding pools. These pools often hold large concentrations of salmon and due to the relatively small pool size, anglers are able to locate and fish their quarry very effectively. The Provinces of New Brunswick and Quebec recognized the vulnerability of salmon to overexploitation by angling, and as a result, designated specific sections of some headwater streams as sanctuaries for salmon. In New Brunswick, the upper reaches of the Northwest Upsalquitch, Dungarvon and Northwest Miramichi rivers have been closed to angling for the past two to three decades. In 1976 the Bartholomew River was closed to angling, except for brook trout (Salvelinus fontinalis) in the spring. Since 1980, angling has been disallowed on headwater stretches of the Kedgwick, Little Main Restigouche and Southeast Upsalquitch Rivers in the Restigouche system, and on the North

Branch of the Main Southwest Miramichi River. In 1979, the headwaters of the Little Southwest Miramichi, and in 1982, all but the lower 1 km of the North Pole were added to the growing list of Closed Waters (Fig. 1). Approximately 13 and 25 percent of the fishable salmon waters of the Miramichi and Restigouche rivers respectively are closed to angling.

Closed Waters are patrolled by the Department of Natural Resources and Energy (DNRE) of the Province of New Brunswick and the Department of Fisheries and Oceans (DFO) of the Federal Government. Patrols are carried out on foot, by canoe and by vehicle. On some waters aircraft are also utilized. The protection effort on the headwaters of the Northwest Upsalquitch, Dungarvon and North Branch of the Main Southwest Miramichi rivers is described below.

Prior to 1979, protection on the Closed Water of the Northwest Upsalquitch River was provided by eight provincial wardens working in pairs and stationed throughout the season at four camps located at major holding pools. The wardens also patrolled stretches between pools. An additional four to six provincial and two federal officers made supplementary, but infrequent patrols from their offices located 50 to 128 km, by road, from the river.

Prior to 1980, patrols on the Closed Waters of

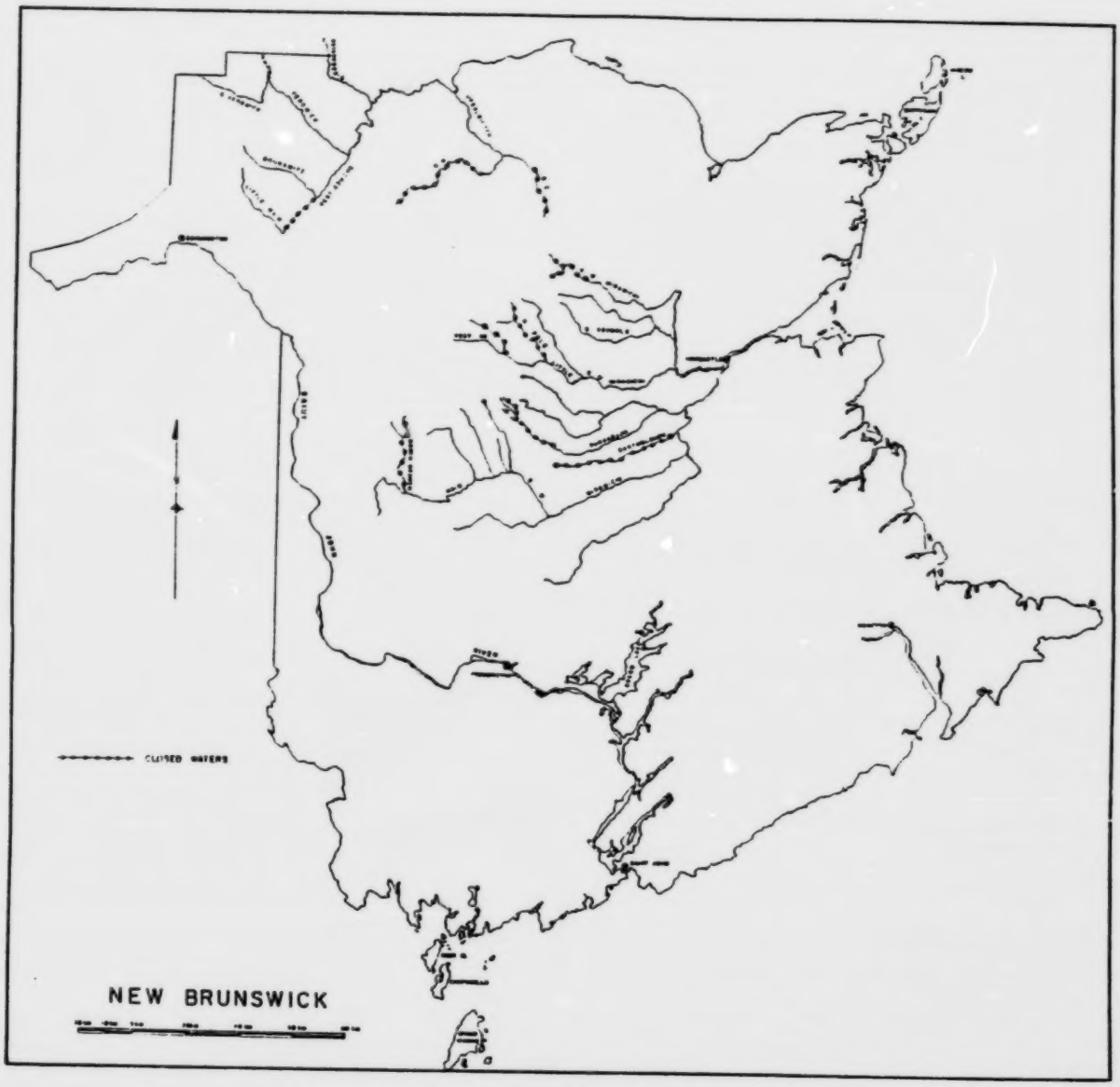


Figure 1. Miramichi and Restigouche drainage waters which are closed to angling.

the Dungarvon River were executed two days per week by three federal wardens stationed at Blackville, 77 km distant, and seven days per week by one to two provincial wardens stationed at a camp on the river. The camp is located 52 km from the nearest provincial office.

Patrols by provincial or federal officers on what are now the Closed Waters of the North Branch of the Main Southwest Miramichi were infrequent prior to 1980. The DNRE had a warden camp on the river which is situated 140 and 35 km by road, from the nearest federal and provincial offices, respectively. One warden hired by the landowner and stationed on the river, executed most of the patrols.

Although these waters were patrolled, illegal fishing activity was prevalent. In 1978, DNRE staff determined that minimums of 61% and 48% of the salmon on the Closed Waters of the Northwest Upsalquitch were removed by poachers in 1975 and 1978, respectively (Appendix I). In those years wardens increased their efforts to curtail the illegal fishing but they had limited success. The illegal fishing was associated with criminal acts, viz three warden camps were burned by arsonists and in separate incidents a provincial and federal officer were physically assaulted by salmon poachers.

A comprehensive plan for the enhancement of the Northwest Upsalquitch salmon stocks was developed (Madden, 1978), and implemented in 1979. The strategy was to contain the salmon in one pool often referred to as a barrier pool, and to concentrate the enforcement effort at that location. Immediately prior to spawning, the fish would be released and allowed to move to the spawning grounds upstream where they would be protected by the wardens. The objectives, in order of priority, were to: (1) increase spawning escapement, (2) evaluate an alternate protection method, and (3) determine whether the salmon used traditional spawning grounds upstream from the project site.

In 1980, similar projects were established on the Dungarvon and North Branch of the Main Southwest Miramichi rivers.

Other jurisdictions have independently conceived the barrier concept. Projects, similar in strategy but less sophisticated, were conducted on a tributary to the Vosso River, Norway in 1971 (Russel, pers. comm.); the Dartmouth and St. Jean rivers on the Gaspe Peninsula, Quebec in 1977 (Cote and LeBlanc, pers. comm.); the Causapscal River on the Gaspe Peninsula from 1984 to 1986 (Fortin, pers. comm.); the Grande Riviere on the Gaspe Peninsula from 1984 to 1986; and the St. Jean River again in 1985 and 1986 (LeGault,

pers. comm.).

A literature search using computer revealed no other papers written on this topic.

In this paper we report on the methods and evaluation of a practical technique for increasing the survival of early-run salmon on the Northwest Upsalquitch, Dungarvon and North Branch of the Main Southwest Miramichi rivers, based on results obtained from 1979 to 1986.

STUDY AREAS AND SITE SELECTION

Northwest Upsalquitch River

The Northwest Upsalquitch River is one of five major Restigouche River tributaries (Fig. 1) and has long been popular among salmon anglers. It drains a mixed-wood forest area of 750 km^2 in Restigouche County, New Brunswick. The main stem is 60 km in length, averages 30 m in width, has a stream gradient of 5.6 m km^{-1}, and a mean annual discharge of 12.8 m^3s^{-1} (Table 1). The lower 16 km of river is a Provincial Crown Angling Reserve limited to 4 rods per day. The adjacent, upper 50 km of river has been closed to angling for 30 years and contains 1,096,600 m^2 of accessible salmon habitat. Six roads provide access to the water's edge (Fig. 2). The river and surrounding terrain is Provincial Crown property which is

Table 1. Stream flow parameters for the Northwest Upsalquitch, Dungarvon and North Branch of the Main Southwest Miramichi rivers, N.B.*

River	Discharge (m^3s^{-1}) Min. Daily	Max. Daily	Mean Annual
Northwest Upsalquitch	0.7	207.0	12.8
Dungarvon	0.6	300.0	14.2
North Branch Main Southwest Miramichi	0.3	125.0	7.1

* Source: New Brunswick Dept. of Municipal Affairs and Environment Calculations based on data collected from hydrometric gauges on the Main Upsalquitch River at Upsalquitch (1918-84), the Renous River at McGraw Brook (1965-84) and the Becaguimec Stream at Coldstream (1974-84), respectively.

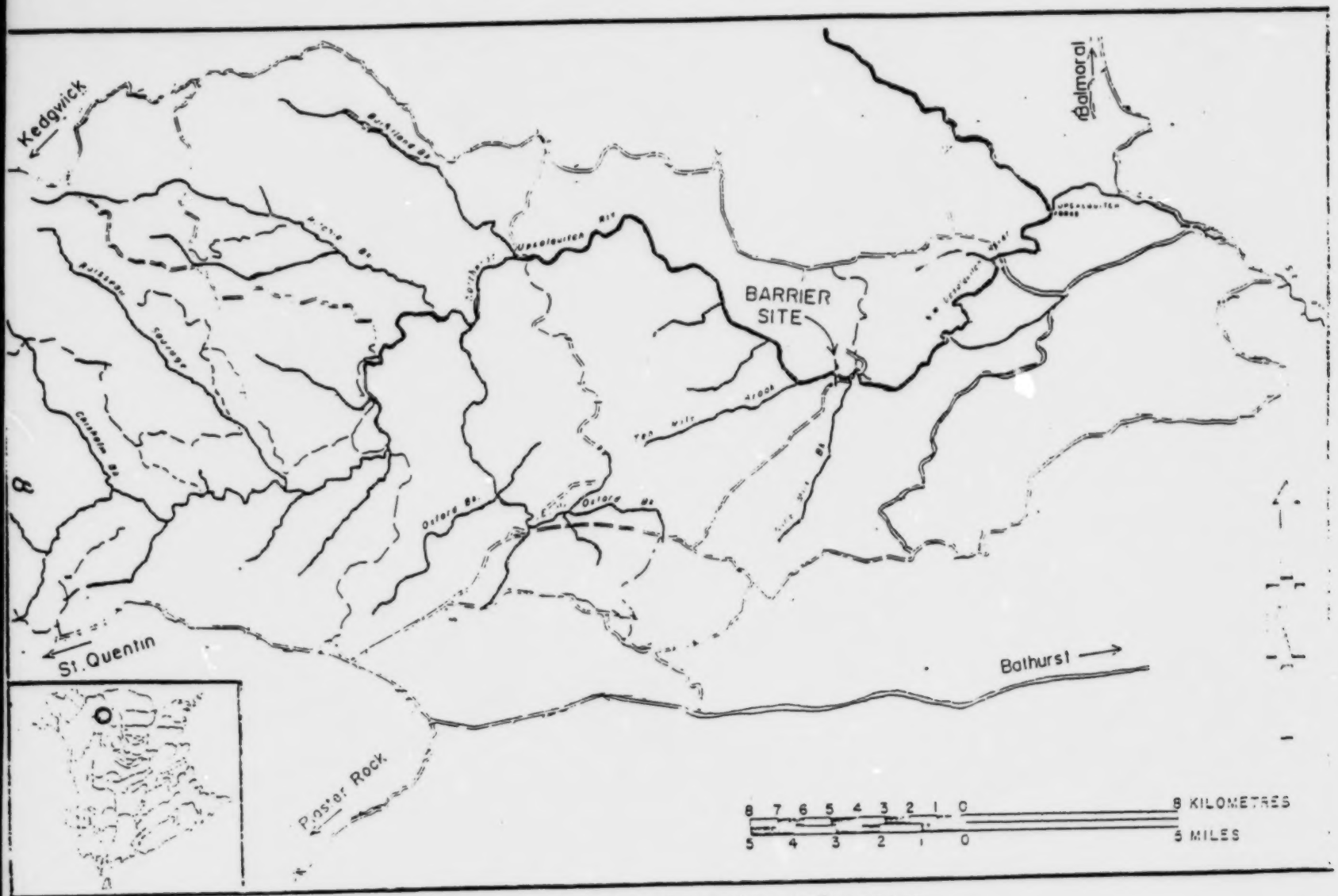


Figure 2. Northwest Upsalquitch River, barrier location and access.

uninhabited.

Ten Mile Pool, the site of the barrier project, is located 100 km upstream from the head of tide and approximately 400 m upstream from the lower boundary of the Closed Water. The pool has a length, average width and maximum depth of 240, 30 and 6 m, respectively. The substrate at the head of the pool is 70% coarse gravel and 30% rubble and at the tail of the pool is 100% coarse gravel.

Ten Mile Pool was selected as the site for the following reasons: (1) the pool is the largest within the Closed Water and can easily accomodate the run; (2) it was included in the Crown Angling Reserve but immediately adjacent to the Closed Water; (3) it has two cool water springs; (4) access to the site by road already existed; and (5) a warden camp was already stationed at the pool.

Dungarvon River

The Dungarvon River is a major tributary of the Miramichi watershed (Fig.1) and is a popular salmon angling river. It drains a softwood forest area of 626 km^2 in Northumberland County, New Brunswick. The main stem is 80 km in length, averages 23 m in width, has a stream gradient of 11.4 m km^{-1}, and has a mean annual discharge of 14.2 m^3s^{-1} (Table 1).

The lower 70 km of river is classed as Crown Open water, i.e., it is owned by the Province of New Brunswick and, therefore, public access is guaranteed. Directly upstream from the Open Water is a 10 km stretch of main stem that, with its two branches, has been closed to angling for more than 20 years. The closed portion contains 152,040 m^2 of habitat accessible to salmon.

Two roads provide access to the closed section. One road crosses the river 3 km downstream from the lower boundary of the closed water while the other is the Plaster Rock-Renous Highway which crosses both branches (Fig. 3). Except for one camp, the upper reaches of the river are uninhabited and are owned by the Province.

Frying Pan Pool, the site of the barrier project on the Dungarvon, is situated 50 m upstream from the lower boundary of the closed water, about 80 km upstream from tidewater. The pool has a length, average width and maximum depth of 92, 18 and 1 m, respectively. The substrate at the head of the pool consists of 30% coarse gravel, 50% rubble and 20% rock; and the substrate at the tail of the pool consists of 50% rubble and 50% rock.

The pool was chosen for the following reasons: (1) it is considered to be sufficiently large to

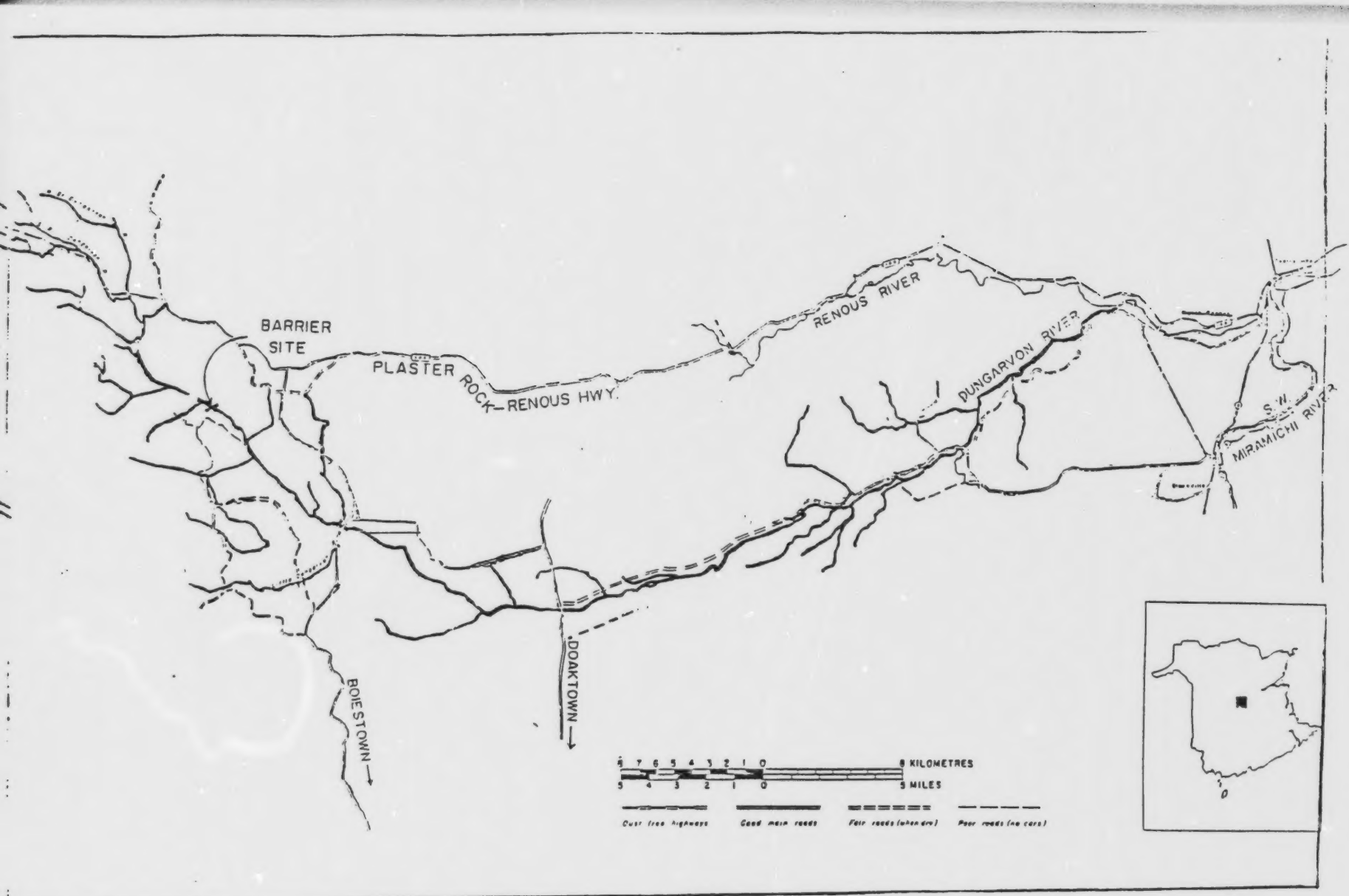


Fig. 3 Dungarvon River, barrier location and access.

accommodate the run; (2) it is fed by two cold water springs; (3) it is near the lower extremity of and within the Closed Water section; (4) the view of the pool from a warden camp would be unobstructed and (5) road construction cost would not be prohibitive. A road, 1 km in length, was built to gain access to the project site.

North Branch of Main Southwest Miramichi River

The North Branch of the Main Southwest Miramichi (Fig. 1) is well known by anglers for its salmon and trophy sea-run brook trout fisheries. The North Branch drains an area of 300 km^2 in Victoria and Carleton Counties, New Brunswick. The surrounding forest is comprised of 50% softwood, 40% mixed wood and 10% hardwood, most of which is owned by J.D. Irving Ltd. The main stem of the Branch is 55 km in length, averages 20 m in width, has a stream gradient of 2.9 m km^{-1} and has a mean annual discharge of 7.1 m^3s^{-1} (Table 1).

The 47 km of main stem upstream from and including Bridge Pool, has been closed to fishing after July 1 since 1980. The Closed Water section is uninhabited and access to it is controlled by J.D. Irving Ltd. (Fig. 4). Exclusive of tributaries, the Closed Water contains 710,700 m^2 of habitat accessible to salmon.

Bridge Pool, the site of the barrier project,

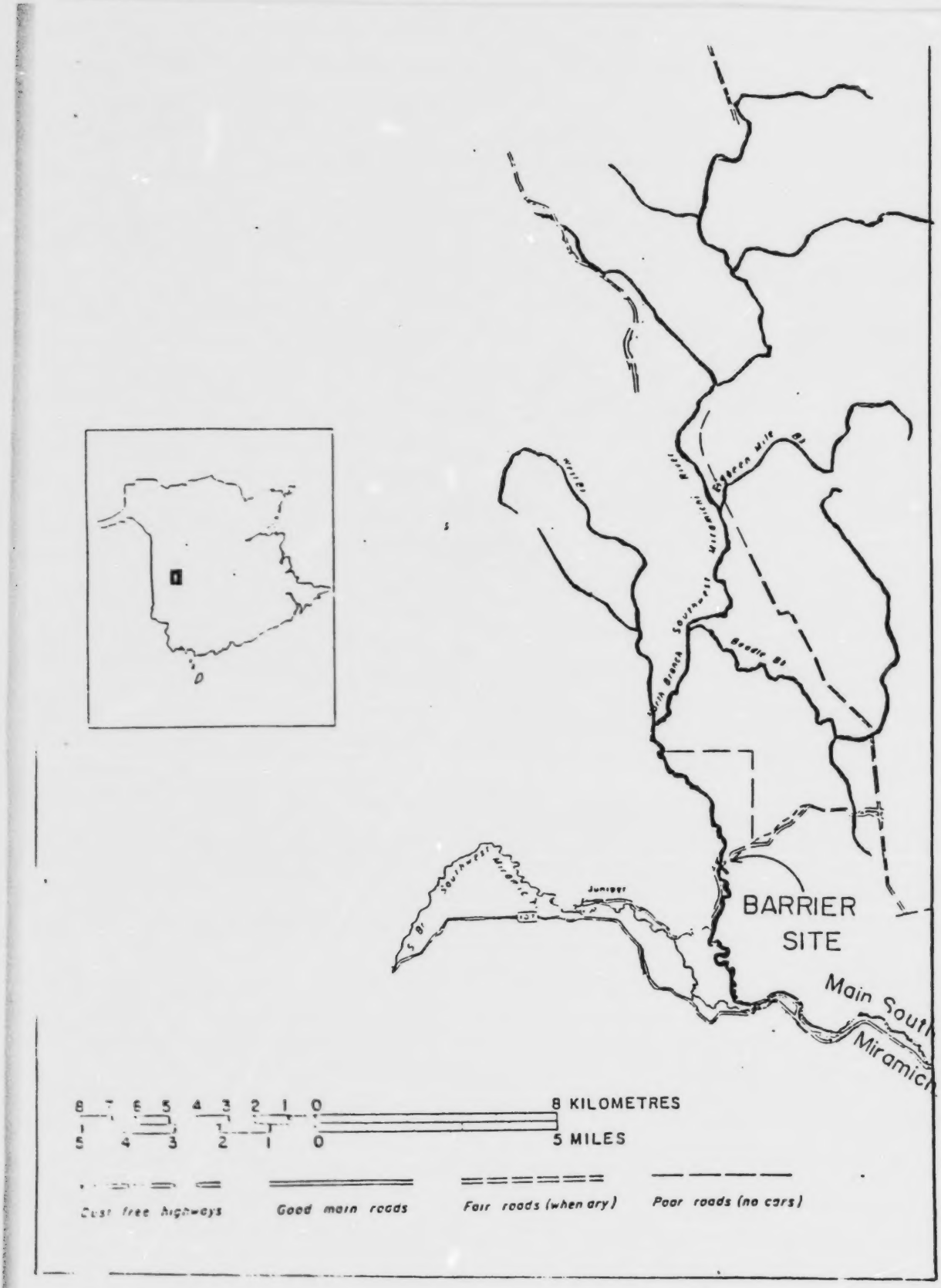


Fig. 4 North Branch of the Main Southwest Miramichi River, barrier location and access.

is located 8 km upstream from the confluence with the South Branch and is about 168 km upstream from the head of tide. The pool has a length, average width and maximum depth of 210, 35 and 3 m, respectively. The substrate is primarily comprised of gravel.

Bridge Pool was selected for the following reasons: (1) it is a recognized holding pool; (2) a road to the pool already existed; (3) it has a cool water spring; (4) it has an electrical power source and (5) the view of the pool from a warden camp would be unobstructed.

METHODS AND MATERIALS

Barrier Design

Not all barrier systems were identical in design. In general, they consisted of three main components: a debris collector upstream, an upstream barrier and a downstream barrier into which a fish trap was incorporated (Fig. 5).

The debris collector was constructed of galvanized chain link fencing 3 m in height, (5 mm diameter wire with a 5 cm square hole size) stretched across the stream and extending well onto the banks. The ends were securely fastened to large trees. Vertical support was provided by paired, 3 m "A" frame metal or wooden

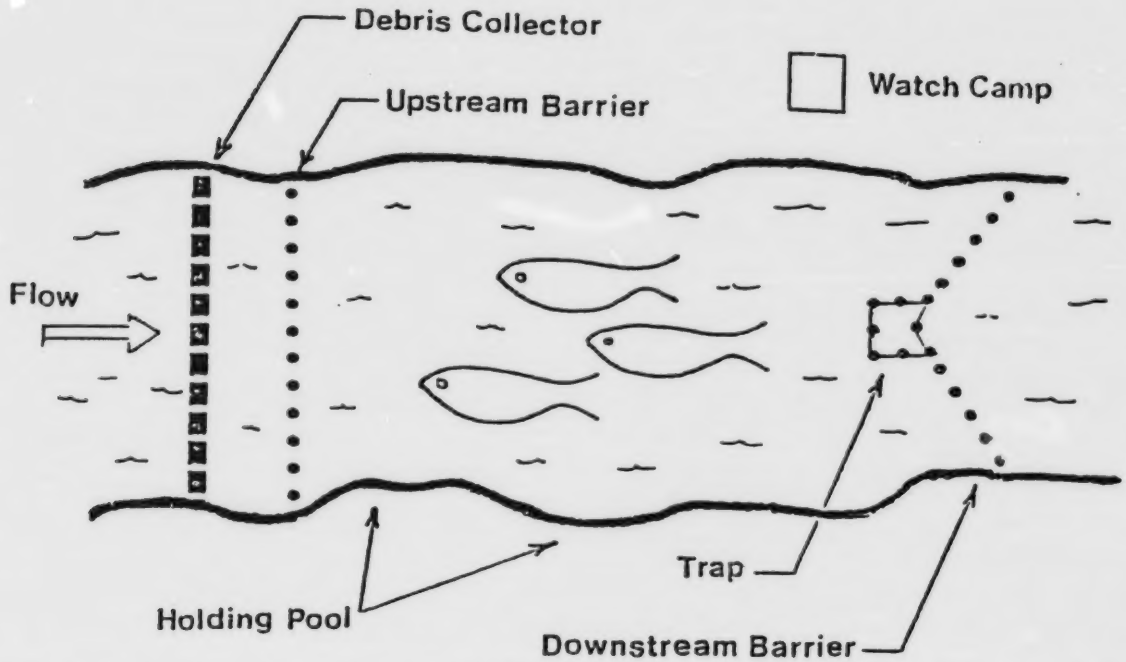


Figure 5. Schematic representation of a typical Salmon Protection Site.

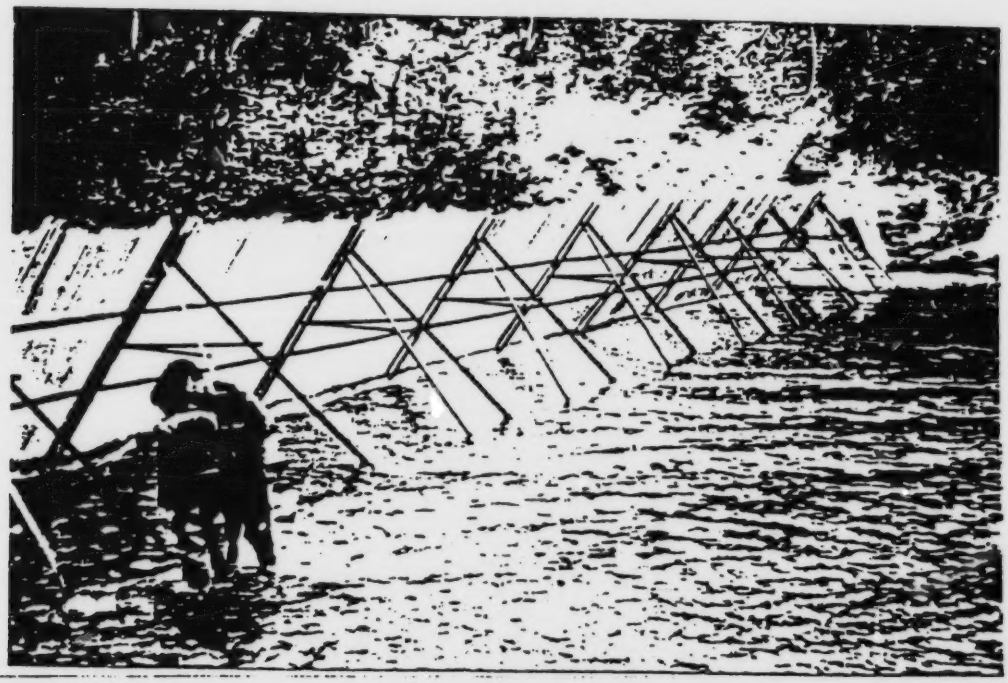


Figure 6. Construction of upstream barrier. River flow is from left to right.

uprights, which were fastened to the top of the fence. The bottom 1 m of the fence was slanted upstream to form an apron upon which large rocks were placed. Aircraft cable (4.8 mm diameter) was woven through the top of the fence and winched tight. Guy lines of the same material were spaced 3 m apart, attached to the top cable, and anchored upstream to steel rods driven 1 m into the substrate. Additional steel rods were driven through the apron.

The upstream barrier at the Northwest Upsalquitch site was originally constructed of wood, but was replaced by metal in 1980. The Northwest Upsalquitch and Dungarvon upstream barriers are a modified design of that described by Anderson and McDonald (1978): they consisted of metal supports constructed of two pieces of angle iron, 50 mm in width attached to a 3 m long, 62.5 mm diameter, galvanized steel pole, to form a tripod. The tripods were used to support three horizontal crosspieces of 76 mm channel iron, mounted on the upstream face. Holes 19 mm in diameter, spaced at 38 mm centres, were punched in the horizontal cross-pieces. Galvanized steel conduit was passed through the holes. The face of the barriers was tilted downstream at approximately a 60 degree angle (Fig. 6).

The North Branch barrier consisted of a vertical structure, comprised of 100 mm diameter aluminum support

posts 2.6 m in length, driven to a depth of approximately 1 m into the substrate. Two horizontal crosspieces of 76 mm aluminum angle were mounted to the support posts. Conduit was installed in the same manner as in the Northwest Upsalquitch and Dungarvon barriers. The barriers crossed the rivers at an angle of approximately 70 degrees to the stream flow.

The Northwest Upsalquitch and Dungarvon downstream barriers were constructed of chain-link fencing similar in design to the debris catchers. The construction of the North Branch downstream barrier was similar to that of the upstream barrier. All three downstream barriers formed a "V" which guided salmon migrating upstream into a counting trap. Two of the traps were of wood frame and 25 mm wire mesh construction, the third consisted of aluminum and conduit.

All three sites were illuminated by 150-500 watt floodlights located near the upstream barrier, the pool centre, and the downstream barrier. Lights were not directed onto the pool surface or fish traps. Electricity was supplied by a 10,000 watt diesel generator at the N.W. Upsalquitch and Dungarvon sites.

Operation

Five to eight DNRE wardens in one or two man teams working 12 hour shifts provided 24 hour

surveillance. The Northwest Upsalquitch site also utilized watch dogs. Patrols by Federal and additional Provincial staff supplemented those of the barrier crews.

The Northwest Upsalquitch accommodations consisted of a watch camp, sleeping and eating quarters. A watch camp located at the pool, together with a larger camp for off duty staff located approximately 300 m distant, provided accommodations at the Dungarvon site. Accommodations at the North Branch site consisted of a 7 m travel trailer located on the river bank, near the pool centre.

On-site communications equipment included telephone and/or portable 2-way radios.

The timing of barrier installations and removal varied annually depending upon fiscal constraints.

Routine daily job requirements included continuous surveillance, inspection, cleaning, maintenance of the barrier and recording of water temperatures and levels. Fish traps were checked periodically day and night, the frequency depending upon the magnitude of the run. The time of trap inspection and the number of salmon and other fish species entering the trap were recorded.

The average number of fish arriving at the barriers per day, by week was calculated by adding the number

of fish arriving each day, and dividing by the number of days in each weekly period. In some weeks, more or fewer than seven days were used to calculate the daily average.

Most fish were not measured but were categorized visually according to approximate length. Fish under 63 cm fork length were classified as grilse. Fish were inspected for injuries and tags, and were subsequently released into the holding pool. Fish mortalities, injuries or abnormal behavior occurring within the holding pools were recorded. Some dead salmon were subjected to pathological examination.

A total of 133 fish were tagged on the Northwest Upsalquitch in 1979, 96 on the Dungarvon and 67 on the North Branch, between 1979 and 1981, in order to assess upstream dispersal, after release. Three tag types were employed, all of which were highly visible.

(1) 6 mm fluorescent orange or blue-white combination modified carlin type tags, attached dorsally with 0.3 mm stainless steel wire.

(2) 20 mm fluorescent orange, yellow or white, modified floy type tags anchored dorsally by a 70 mm plastic T-bar using a Dennison Super Swiftach MK II gun.

(3) 250 mm lengths of fluorescent green and orange

yarn attached dorsally.

Investigators in canoes or on foot searched for tagged fish upstream from the barriers after the fish were released.

Upstream barriers and debris collectors were removed between mid-September and early October in order to allow upstream migration of spawners. When necessary, beaver dams and other obstructions were removed a few days before the fish were released. Wardens and other DNRE staff monitored fish movement and provided protection of spawners.

Counts of spawning salmon and/or redds were conducted on foot and from canoe upstream from the barrier sites in October and November. Redd counts executed by DNRE on the Closed Waters of the Northwest Upsalquitch River from 1970-79 are presented for comparative purposes. Redd counts upstream from Ten Mile Pool were also compared with those executed downstream from the Pool and with those on the Southeast Upsalquitch River, before and after the barrier concept was implemented.

Juvenile salmon densities were measured by electroseining in order to confirm utilization of traditional spawning areas. Electroseining was executed at 10 sites on the Northwest Upsalquitch in 1981, three sites on the Dungarvon and three sites on the

North Branch in 1980 and 1981.

RESULTS

Run Magnitude and Timing

Northwest Upsalquitch River

The number of salmon counted at the Ten Mile Pool trap ranged from 731 in 1983 to 2905 in 1986 with a mean of 1434 (Table 2 and Fig. 7). These counts represent the minimum number of salmon reaching the Pool, because in some years, breaching of the fence, defined as water flowing around, scouring under or overflowing the fence may have allowed salmon to proceed past the counting fence without being enumerated. The counting fence operated annually from mid-June to late October (Table 3). It is estimated that no more than a total of 20 salmon arrive before and after the operation of the counting fence.

The Northwest Upsalquitch River has an early run and late run of Atlantic salmon (Fig. 8). The peak runs occur in July and from late September to mid-October with approximately 75% of the run occurring during these times. The peak in the arrival of salmon and grilse occurs in the second and third week in July, respectively.

TABLE 2. The number of Atlantic salmon and grilse counted, by month, at Ten Mile Pool on the Northwest Upsalquitch River, N.B., 1980-86.

Month	1979		1980		1981		1982		1983		1984		1985		1986	
	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse
June			33	12	7	6	26	2	49	5	29	3	23	1	132	56
July			501	469	231	505	125	407	163	246	346	278	261	277	467	976
August			253	297	142	141	74	257	12	108	76	130	93	287	231	353
September			39	31	38	37	144	85	19	24	6	33	21	72	141	153
October			61	34	66	106	52	67	59	46	182	73	123	97	195	201
TOTAL	245	733	887	843	484	795	621	818	302	429	639	517	521	734	1166	1739
TOTAL FISH	978		1730		1279		1439		731		1156		1255		2905	

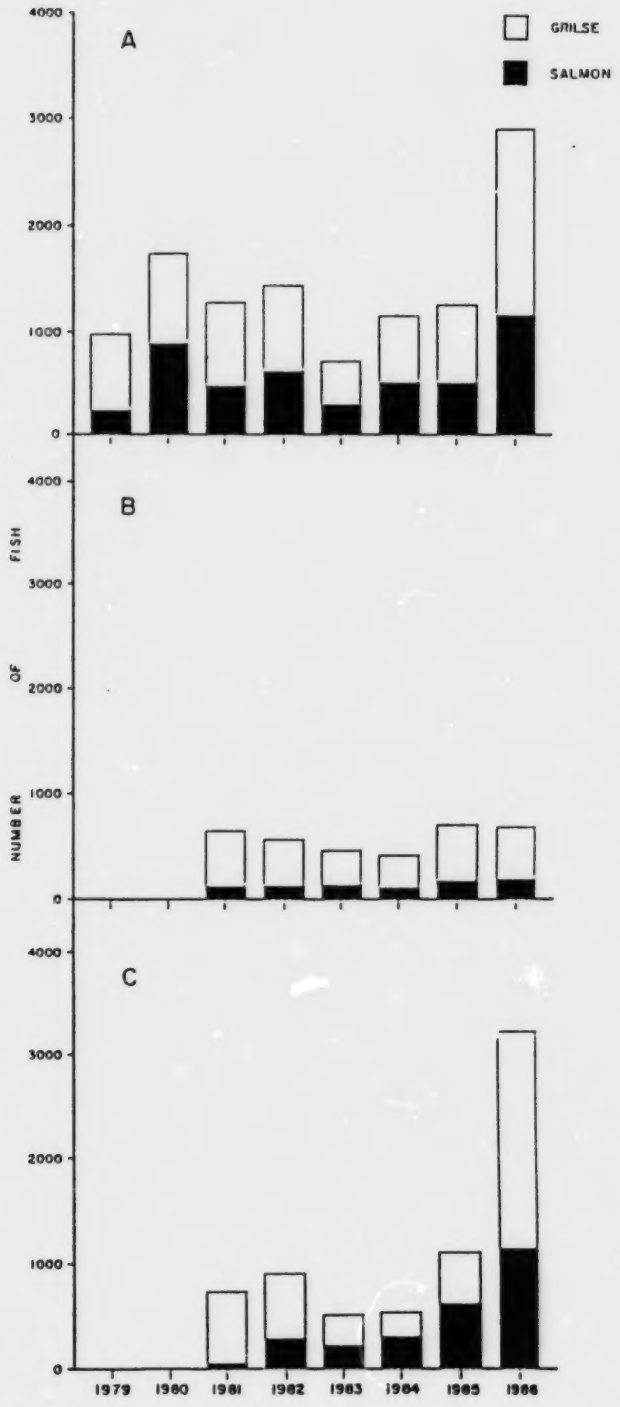


Figure 7. Annual counts of Atlantic salmon and grilse at the counting fences on Northwest Upsalquitch (A), Dungarvon (B), and North Branch of the Main Southwest Miramichi (C) rivers, N.B., 1979-86.

TABLE 3. Dates of operation of the Atlantic salmon barriers on the Northwest Upsalquitch, Dungarvon and North Branch of the Main Southwest Miramichi rivers, N.B., 1979-86.

Year	Northwest Upsalquitch		Dungarvon		North Br. Main Southwest Miramichi	
	Dates Operated	No. of Days	Dates Operated	No. of Days	Dates Operated	No. of Days
1979	June 19 - Oct. 26	130				
1980	June 17 - Oct. 8	114	Aug. 7 - Oct. 10	64	July 21 - Oct. 13	84
1981	June 8 - Oct. 23	138	June 24 - Oct. 8	107	July 5 - Oct. 4	91
1982	June 15 - Oct. 23	131	June 28 - Oct. 15	110	June 30 - Oct. 8	101
1983	June 20 - Oct. 24	127	June 27 - Oct. 14	110	July 4 - Oct. 10	98
1984	June 19 - Oct. 24	128	July 5 - Oct. 12	100	July 10 - Oct. 16	98
1985	June 14 - Oct. 27	136	June 25 - Oct. 10	108	July 1 - Oct. 20	112
1986	June 17 - Oct. 23	129	June 25 - Oct. 21	119	June 30 - Oct. 19	112

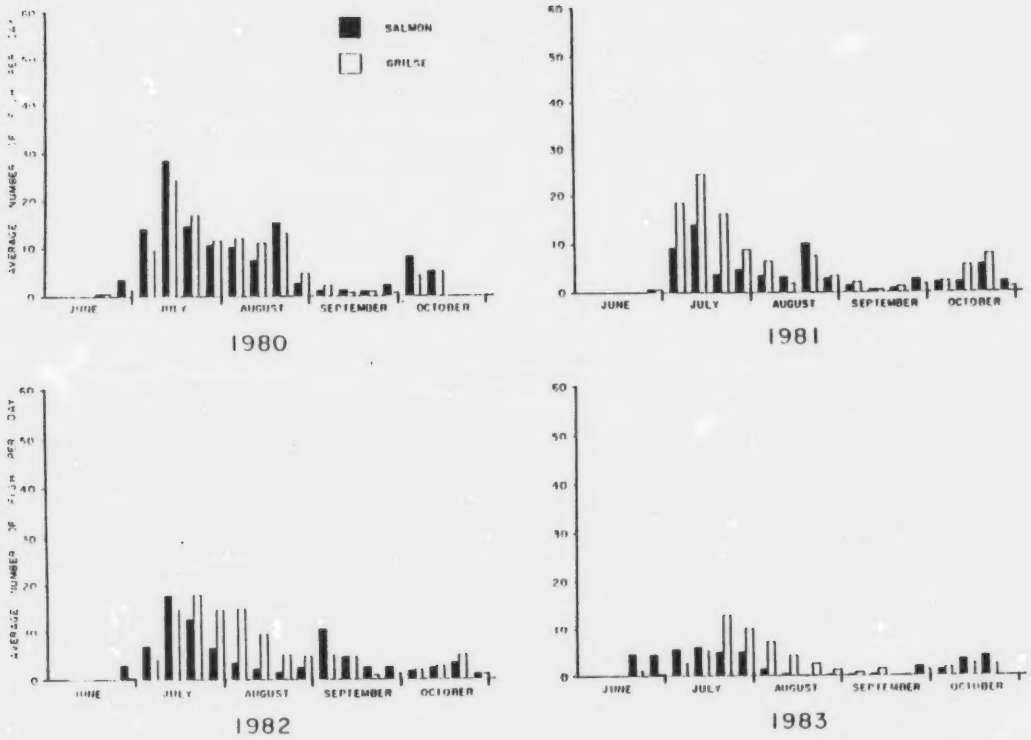


Figure 8a. Average number of Atlantic salmon and grilse counted per day at Ten Mile Pool, Northwest Upsalquitch River, N.B., by week, 1980-83.

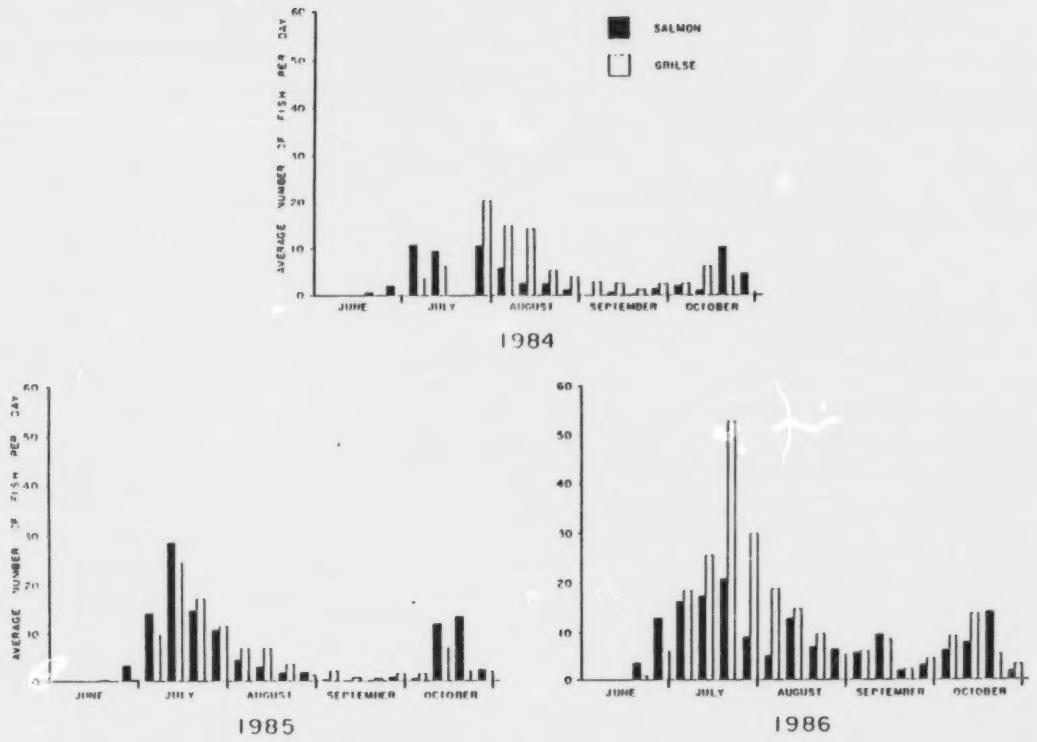


Figure 8b. Average number of Atlantic salmcn and grilse counted per day at Ten Mile Pool, Northwest Upsalquitch River, N.B., by week, 1984-86.

Dungarvon River

The number of salmon counted at the Frying Pan Pool trap ranged from 408 in 1984 to 698 in 1985 with a mean of 585 (Table 4 and Fig. 7). These counts represent the minimum number of salmon reaching the Pool, for reasons described earlier. The counting fence operated from late June to mid-October each year (Table 3). Probably less than 150 fish arrive before and after the operation of the fence.

The Dungarvon River has a predominately early summer run of Atlantic salmon (Fig. 9) with a smaller peak in the fall. The peak of the run occurs from late June through July with approximately 75% of the run occurring during this period. The peak in the arrival of salmon and grilse occurs in the first week of July. Five fish tagged at the Millbank trap prior to mid July were recaptured at Frying Pan Pool an average of 13.4 days later. Two fish tagged after the middle of July were recaptured an average of 67.5 days later (Table 5).

North Branch of the Main Southwest Miramichi River

The number of salmon counted at the Bridge Pool trap ranged from 509 in 1983 to 3210 in 1986 with a mean of 1162 (Table 6 and Fig. 7). These counts represent the minimum number of salmon reaching the

TABLE 4. The number of Atlantic salmon and grilse counted, by month, at Frying Pan Pool on the Dungarvon River, N.B., 1980-86.

Month	1980		1981		1982		1983		1984		1985		1986	
	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse
June			29	80	14	35	0	2	0	0	17	12	34	33
July			67	380	72	332	89	235	86	256	113	425	74	245
August	28	45	5	46	8	45	17	62	6	29	12	33	11	45
September	42	52	9	24	24	73	8	6	1	16	15	51	20	61
October	23	31	2	20	2	4	12	25	0	14	5	15	35	117
TOTAL	93	128	112	550	120	489	126	330	93	315	162	536	174	501
TOTAL FISH	221		662		609		456		408		698		675	

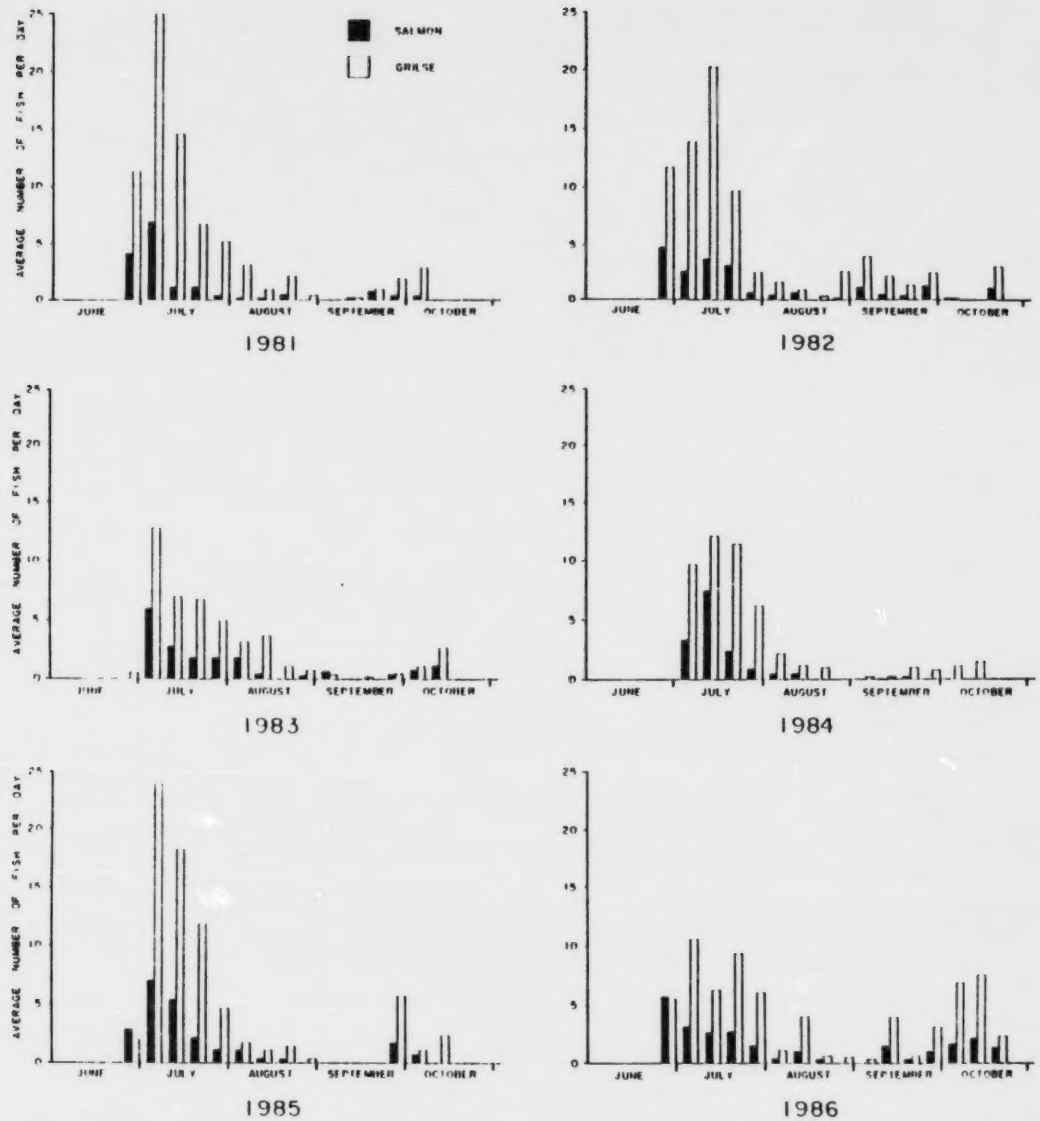


Figure 9. Average number of Atlantic salmon and grilse counted per day at Frying Pan Pool, Dungarvon River, N.B., by week, 1981-86.

TABLE 5. Recapture at Frying Pan Pool data for Atlantic salmon from the Millbank estuarial trap to the Dungarvon River fish trap (E. Schofield, pers. com.)

Year	Date Tagged	Date Recaptured	Time at Large (Days)
1985	30 June	9 July	10
	1 July	13 July	13
	19 July	24 Sept.	68
	26 July	30 Sept.	67
1986	21 June	5 July	15
	22 June	4 July	13
	2 July	17 July	16
		mean	28.9

TABLE 6. The number of Atlantic salmon and grilse counted, by month, at Bridge Pool on the North Branch of the Main Southwest Miramichi River, N.B., 1981-86.

Month	1981		1982		1983		1984		1985		1986	
	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse
June			5	6							1	5
July	16	341	63	137	67	100	76	121	209	206	194	458
August	15	171	64	142	16	87	12	46	31	128	96	344
September	21	145	144	321	46	51	94	47	104	93	473	891
October	2	14	6	15	90	52	115	16	260	65	374	384
TOTAL	54	671	282	621	219	290	297	230	604	492	1138	2072
TOTAL FISH	725		903		509		527		1096		3210	

Pool, for reasons described earlier. The counting fence operated annually from early July to mid-October (Table 3). Probably less than a total of 200 salmon arrive before and after the operation of the counting fence.

The North Branch of the Main Southwest Miramichi River has an early run and late run of Atlantic salmon (Fig. 10). The peak runs occur in July and from late September to mid-October, with approximately 65% of the run occurring during these times. The peak arrival of salmon occurs from early September to mid-October. The peak arrival of grilse varies from year to year, but generally occurs prior to the peak salmon run.

Salmon - Grilse Composition

The percentage of large salmon on the Northwest Upsalquitch ranged from 38% in 1981 to 55% in 1984 with a mean of 44 % (Table 7). The percentage of large salmon on the Dungarvon River ranged from 17% in 1981 to 28% in 1983 with a mean of 22 %. The percentage of large salmon on the North Branch of the Main Southwest Miramichi ranged from 7% in 1981 to 56% in 1984 with a mean of 37 %.

Run Timing vs. Water Levels

A positive correlation is evident between acute

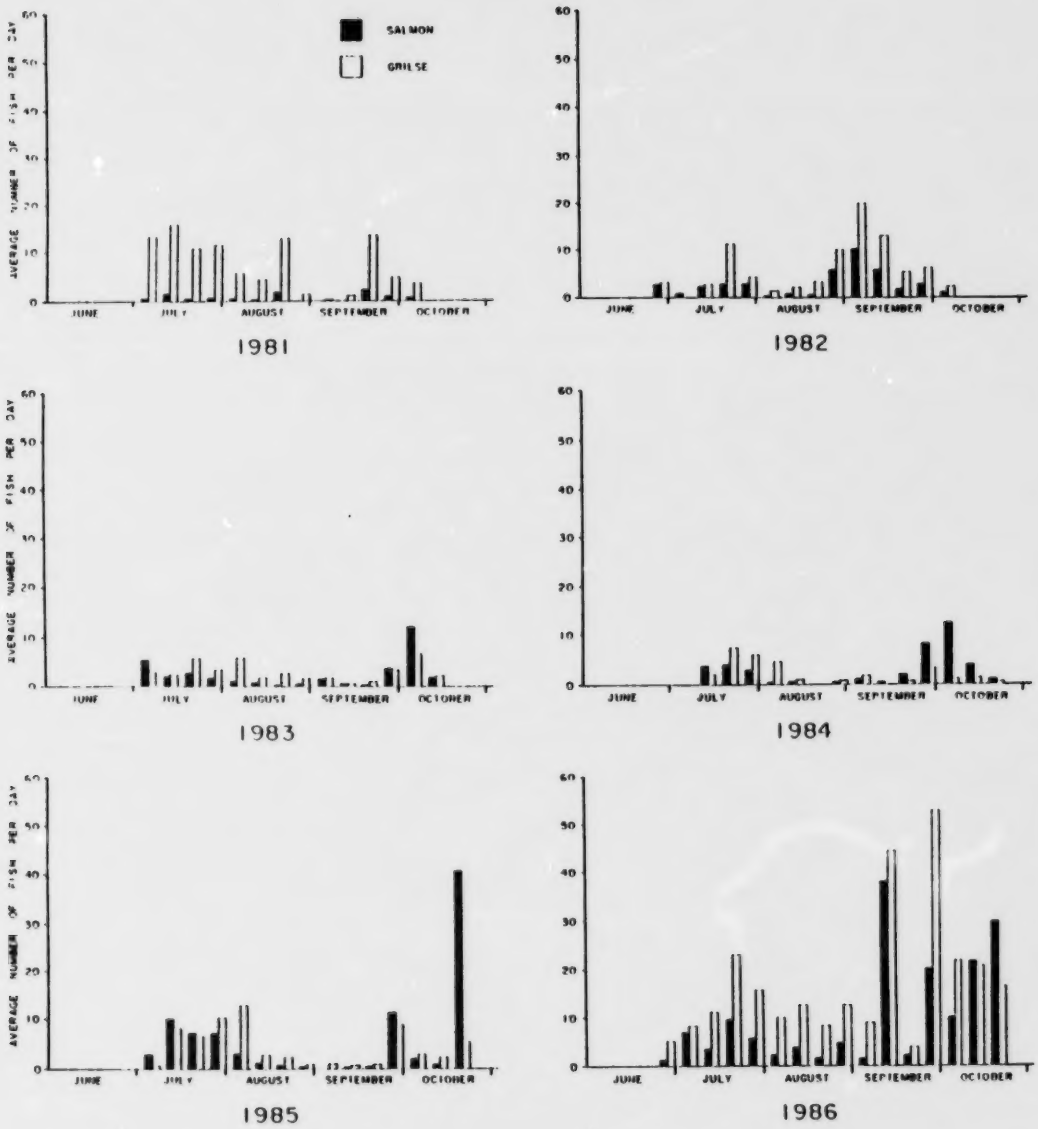


Figure 10. Average number of Atlantic salmon and grilse counted per day at Bridge Pool, North Branch of the Main Southwest Miramichi River, N.B., by week, 1981-86.

TABLE 7. The number of Atlantic salmon and grilse counted annually on the Northwest Upsalquitch, Dungarvon and North Branch of the Main Southwest Miramichi rivers, N.B., 1980-86.

	Northwest Upsalquitch Ten Mile Pool				Dungarvon Frying Pan Pool				North Br. Main Southwest Miramichi Bridge Pool			
	Salmon		Grilse		Salmon		Grilse		Salmon		Grilse	
Year	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1980	887	51	843	49								
1981	484	38	795	62	112	17	550	83	54	7	671	93
1982	621	43	818	57	120	20	489	80	282	31	621	69
1983	302	41	429	59	126	28	330	72	219	43	290	57
1984	639	55	517	45	93	23	315	77	297	56	230	44
1985	521	42	734	58	162	23	536	77	604	55	492	45
1986	1166	40	1739	60	174	26	501	74	1138	35	2072	65
TOTAL	4620	44	5875	56	787	22	3508	78	2594	37	4376	63
MEAN	660		839		131		585		432		730	

rises in water levels and increased counts of salmon at the barriers (Appendix II). Similar results have been described by Jessop (1986).

Breaches

Two breaches at Ten Mile Pool resulted from high water flowing over or around the fence, while three breaches were attributed to scouring (Table 8). Two of the three breaches at Frying Pan Pool resulted from scouring; the other caused by extreme water pressure bending the conduit pipes of the trap. All seven breaches at Bridge Pool were attributed to scouring.

Fish escapement was detected on one occasion at each of the Northwest Upsalquitch and Dungarvon fences by observing fish trapped between the upstream fence and debris collector. These fish, which exceeded 800 on the Northwest Upsalquitch in 1979, were seined and returned to the holding pool.

Survival to Spawning

Not all salmon that arrived at the counting fences survived to spawn. Mortality was categorized as occurring within the holding pool (natural causes or physical injury) or due to illegal harvest upstream from the holding pools upon release.

TABLE 8. Dates of breaches of the counting fences on the Northwest Upsalquitch, Dungarvon and North Branch of the Main Southwest Miramichi rivers, N.B., 1979-86.

Year	Northwest Upsalquitch	Dungarvon	North Branch Main Southwest Miramichi
1979	7 September [a]		
1980	5 October [a]	4 October [a]	
1981	24 October [c]		
1982			26 August [c] 2 October [b]
1983			23 September [c]
1984	29 June [a]	9 August [a]	9 July [b]
1985	11 July [c]	16 July [b]	15 July [c]
1986			13 September [a] 23 September [a]

a - breach of upper fence
b - breach of lower fence
c - breach of both fences

Mortalities that occurred at Ten Mile Pool during the project ranged from 12 (2.7%) in 1985 to 102 (23.3%) in 1980 with a mean of 55 fish (Table 9). Eighty-seven percent of these mortalities (Table 10) were attributed to furunculosis (Aeromonas salmonicida). The number of fish that were illegally harvested in the Northwest Upsalquitch after release from the pool ranged from 0 in 1983 to 636 in 1981 with a mean of 232 fish. The percentage of salmon surviving to spawn ranged from 43% in 1981 to 94% in 1986 with a mean of 80%.

The number of salmon mortalities recorded at Frying Pan Pool (Table 11) ranged from 1 in 1986 to 10 in 1981 and at Bridge Pool ranged from 1 in 1983 and 1985 to 8 in 1981. The mean survival of fish arriving at the Dungarvon and North Branch of the Main Southwest Miramichi Rivers from 1981 to 1986 was 99.3 and 99.7%, respectively. Provincial, federal and private wardens believe that illegal harvest of salmon upstream from the barrier sites, after 1980, was minimal. There was a fourfold increase in the number of redds upstream from Ten Mile Pool after the inception of the project, compared to a threefold and twofold increase downstream from Ten Mile Pool and on the Southeast Upsalquitch (Table 12), respectively.

TABLE 9. Survival to spawning of Atlantic salmon reaching Ten Mile Pool, Northwest Upsalquitch River, N.B., 1979-86.

Year	No Arrivals at Ten Mile	No Mortalities at Ten Mile	No Released from Ten Mile	No Mortalities upstream from Ten Mile	Salmon arriving at Ten Mile that survived to spawn	
					No.[a]	%
1979	1042	47	995	115	880	84
1980	1730	102	1628	154	1474	85
1981	1279	92	1187	636	551	43
1982	1439	69	1370	328	1042	72
1983	731	39	692	0	692	95
1984	1156	54	1102	301	801	69
1985	1255	12	1243	178	1065	84
1986	2905	23	2882	142	2740	94
TOTAL	11,537	438	11,099	1,854	9,245	80
MEAN	1,443	55	1,387	232	1,156	80

a - assuming 3.2 redds/large salmon based on redd/salmon counts in 1980

Table 10 . Causes of Atlantic salmon mortalities at the counting fences on the Northwest Upsalquitch, Dungarvon and North Branch of the Main Southwest Miramichi rivers, N.B., 1979-86.

Cause	Northwest Upsalquitch		Dungarvon		North Branch Main Southwest Miramichi	
	No.	%	No.	%	No.	%
Furunculosis	382	87	0	0	0	0
Injured in trap	0	0	0	0	10	50
Gilled in chain link fence	0	0	13	42	2	10
Handling	0	0	0	0	3	15
Previous injuries	0	0	5	16	0	0
Predators	0	0	0	0	1	5
Pinned against fence	0	0	5	16	0	0
Unknown	56	13	8	26	4	20
Total	438		31		20	

TABLE 11. Atlantic salmon and grilse mortalities recorded at the counting fences on the Dungarvon and North Branch of the Main Southwest Miramichi rivers, N.B., 1980-86.

Year	Dungarvon		North Branch Main Southwest Miramichi	
	Salmon	Grilse	Salmon	Grilse
1980	0	3		
1981	1	9	1	7
1982	0	2	1	5
1983	0	4	0	1
1984	0	5	0	2
1985	0	6	0	1
1986	0	1	0	2
TOTAL	1	30	2	18

TABLE 12. Rates of increase in spawning escapement upstream from Ten Mile Pool, including tributaries, compared to that downstream from the Main Stem of the Southeast Upsalquitch River before and after barrier concept implementation. Data are used for comparable years only.

Year	No. of Redds Upstream from Ten Mile Pool (50 km)	No. of Redds Downstream from Ten Mile Pool (16 km)	Southeast Upsalquitch (15 km)
1971	124	29	35
1972	251	86	84
1975	576	170	90
1976	667	243	64
1977	924	390	150
1978	411	269	113
Total	2953	1187	536
Mean	492	198	89
1980	3104	528	147
1981	670	100	23
1984	1362	362	218
1985	1379[a]	739	248
1986	3520	1220	296
Total	10035	2949	932
Mean	2007	590	186
% Increase in Means	308	198	109

a - estimated from number of spawners

Spawner Distribution

The proportion of redds upstream from Twenty Mile on the Northwest Upsalquitch River, subsequent to 1979, averaged 45.7% compared to 34.9% prior to 1979 (Table 13).

In 1979, 83 % of the early run fish tagged on the Northwest Upsalquitch spawned upstream from Twenty Mile, w le 94% of the late run spawned downstream from that point (Table 14).

The distribution of redds on the Dungarvon River between Frying Pan Pool to Herb Pond and the Driving Dam to Highway 108 was similar from 1980 to 1983 (Table 15). In 1984, approximately twice as many redds were observed between the Driving Dam to Highway 108 than were observed from Frying Pan Pool to Herb Pond. In 1985, however, approximately ten times as many redds were observed between Frying Pan Pool and Herb Pond than were observed in the Driving Dam to Highway 108 section.

The number of redds observed on the North Branch of the Main Southwest Miramichi River between Bridge Pool and West Brook increased from 1981 to 1986 (Table 16). The decline in the number of redds recorded in 1984 is attributed to surveying only two-thirds of the section.

Electroseining confirmed the presence of juvenile

TABLE 13. Atlantic salmon redd distribution on the main stem of the Northwest Upsalquitch River before and during the Ten Mile Pool barrier project.

Year	Redds between Ten and Twenty Mile No.	%	Redds upstream from Twenty Mile No.	%	Total No. Redds.
Before Project					
1971	--	--	--	--	124
1972	--	--	--	--	251
1973	158	45.7	188	54.3	346
1974	115	50.4	113	49.6	228
1975	419	72.7	157	27.3	576
1976	391	68.8	177	31.2	668
1977	633	68.5	291	31.5	924
1978	270	65.7	141	34.3	411
Sub-Total	1986	65.1	1067	34.9	3528
Mean	331	65.1	178	34.9	441
During Project					
1979	557	74.7	189	25.3	746
1980	1273	41.0	1831	59.0	3104
1981	340	50.7	330	49.3	670
1982	555	39.7	844	60.3	1399
1983	600	57.8	438	42.2	1038
1984	985	77.0	295	23.0	1280
1985	Count not executed because of early freeze-up.				
1986	1968	59.1	1361	40.9	3329
Sub-Total	6278	54.3	5288	45.7	11566
Mean	897	54.3	755	45.7	1652

TABLE 14. Distribution of early and late run spawning salmon on the headwaters of the Northwest Upsalquitch River, 1979. Early run salmon arrived at the Ten Mile Pool and were tagged prior to September 7 and late run salmon were tagged upon arrival between September 7-14. Thirty early run and 103 late run salmon were tagged.

Section	Early Run		Late Run	
	No.	%	No.	%
Upstream from 20 Mile	10	83	5	6
10 Mile - 20 Mile	2	17	75	94
	12	100	80	100

Table 15. Atlantic salmon redd distribution on the main stem of the Dungarvon River, N.B., upstream from Frying Pan Pool, 1980-86.

Year	Number of Redds	
	Frying Pan Pool to Herb Pond (2.1 km)	Driving Dam to Hwy 108 (3.1 km)
1980	10	8
1981	53	41
1982	-	16
1983	46	58
1984	30	61
1985	205	21
1986	-	46*

* North and South Branches from Highway 108 to the forks.

Table 16. Atlantic salmon redd distribution on the main stem of the North Branch of the Main Southwest Miramich River, N.B., 1980-86.

	Number of Redds		
	Downstream from Bridge Pool	Upstream from Bridge Pool	
Year	Gate to Bridge Pool (2.7 km)	Bridge Pool to West Brook (7.2 km)	West Brook to Fifteen Mile Brook (9.9 km)
1980	-	82	118
1981	3	46	-
1982	32	198	-
1983	21	241	-
1984	-	174(1)	-
1985	127	252(2)	-
1986	180	397	-

(1) Belyea to Flanagan and Alder Grounds to Bridge Pool only

(2) Bundy Bank to Bridge Pool only

Atlantic salmon at each of 10 locations on the Northwest Upsalquitch in 1981, three locations upstream from Frying Pan Pool and three sites upstream from Bridge Pool in 1980 and 1981 (Table 17).

Observations of Illegal Fishing Activity

Few poaching attempts were recorded at the three salmon protection pool sites from 1979 to 1986. In 1981, an investigation was conducted on an unauthorized release or escapement of 600 fish from the Ten Mile Pool. (McCormick and McCrea, 1982). Also in 1981, a gill net was discovered in shrubbery near Ten Mile Pool. DNRE staff also discovered a gill net in the Dungarvon River upstream from Frying Pan Pool during the summer of 1984. Several pieces of conduit pipe were removed from the Bridge Pool fish trap by two individuals in 1985.

A noticeable decline in activity along the river upstream from all three projects was observed annually during the summer and early fall operating periods. The reduction in activity continued even after fish were released on the Dungarvon and North Branch of the Main Southwest Miramichi rivers. On the Northwest Upsalquitch, however, poaching activity increased over summer levels after the fish were released.

Table 17. Juvenile Atlantic salmon population estimates per 100 m^2 on the N.W. Upsalquitch in 1981 and on the Dungarvon and North Branch of the Main Southwest Miramichi rivers, N.B., 1980-81.

River	Site	Age Class 0+ 1980	0+ 1981	1+ 1980	1+ 1981	2+ 1980	2+ 1981
Northwest Upsalquitch	Twelve Mile		28		3		1
	Sixteen Mile		28		0		1
	Twenty Mile		41		4		0
	Twenty-Two Mile		24		2		1
	Twenty-Three Mile		24		2		1
	Twenty-Five Mile		17		2		1
	Twenty-Eight Mile		33		1		1
	Thirty-One Mile		55		3		1
	Forty Mile		38		2		1
	Forty-Two Mile		1		18		11
Dungarvon	Upstream Barrier	26	53	8	21	3	6
	Gravel Pit	12	51	21	25	3	6
	North Br. Hwy 108	123	134	25	19	12	3
North Branch	Belyea's Pool	56	25	3	0	0	0
	Broken Toe	54	73	26	8	5	3
	Fifteen Mile	44	78	22	16	3	1

TABLE 18. Approximate capital and operational costs, in 1986 dollars, associated with an Atlantic salmon protection pool project.

Item	Cost ($)
Fence Material*	15,000 - 20,000
Buildings *	12,000 - 20,000
Miscellaneous	5,000
Labour	25,000 - 53,000
Annual Maintenance	5,000

* 1ST YEAR COST'S AS PER TEXT

Costs

Capital costs associated with fence, buildings and other equipment ranged from $32,000 to $45,000 (Table 18). Annual operational costs ranged from $30,000 to $58,000.

DISCUSSION

Run Magnitude and Timing

The annual fluctuations in the numbers of salmon tallied at all three barriers were the result of natural and man-made factors. Since 1984, the enactment and enforcement of more restrictive commercial and recreational harvesting regulations and native food fishery agreements has allowed for increased escapement to the rivers (Anon., 1986) and therefore, the barriers. In addition, increased survival rates of grilse at sea in 1985 to 1986 resulted in large grilse runs in the Restigouche and Miramichi systems (Randall et al, 1986).

The larger increase in spawning escapement upstream from the Northwest Upsalquitch barrier relative to downstream from the barrier and on the Southeast Upsalquitch after 1979, may be due to a greater degree of illegal harvest of stocks on the upper Northwest, prior to 1979. Bearing in mind the high proportion of the run taken by poachers prior to 1979, the dramatic

increase in the number of large salmon reaching Ten Mile Pool in 1986 is attributed mainly to the protection of the parent fish detained in the Pool in 1980. Salmon returning in 1986, which were aged, were found to have smoltified at age three (Pickard, pers. comm.)

There were no other traps in the Restigouche system with which the trend in run magnitude at Ten Mile Pool can be compared. The sites of the two traps operated in the estuary by the Ministere du Loisir, de la Chasse et de la Peche (M.L.C.P.), Quebec were different in both 1985 and 1986.

The majority of grilse and salmon which returned to Frying Pan and Bridge pools in 1985 and 1986, respectively, were assumed to be the progeny of fish detained at the barriers in 1980. The basics for this assumption is that 68% of Miramichi parr smoltified at age three (Elson 1973, Randall, in publ.). Thus the majority of grilse at the barriers in 1986 were offspring of fish protected there in 1981.

At Bridge Pool, the steady and dramatic climb in grilse numbers since 1984 and in the number of large salmon in 1986 indicate that the parent stocks protected there in 1980 and 1981 did survive to spawn and did produce healthy offspring.

The number of large salmon and grilse recorded at Frying Pan Pool in 1986 probably would have been

greater if not for a marked increase in poaching, in that year, on the Renous River downstream from its confluence with the Dungarvon (McCabe and Butler, pers comm.).

The number of large salmon at Bridge Pool in 1986 was 88% greater than the previous highest count which occurred in 1985. This increase is considerably greater than that of 51% reported by Randall (pers. comm.) for the same period at the Millbank estuarial trap (Appendix III). The increase in large salmon at Bridge Pool in 1986 is even more significant when compared to the 33% decrease from 1985 to 1986 in the mean catch per unit effort for large salmon on nine Crown Angling Reserves on the Northwest Miramichi, Sevogle and Little Southwest Miramichi rivers (Dubee, 1986).

Noting the apparent decline in the number of large salmon in the Northwest Miramichi system and the concomitant increase in the Miramichi River at the Millbank estuarial trap, it is probable that the increase in large salmon in the Main Southwest Miramichi immediately upstream from the Northwest was greater than the 51% increase recorded in the estuary. It should be noted, however, that the percentage of large salmon harvested by the Red Bank Native Food Fishery and also the efficiency of the Millbank Trap are

uncertain (Randall, Chadwick and Schofield, 1986). The increase in the Main Southwest Miramichi system, therefore, may have been similar to that at the barrier. This has been supported by anglers who reported the best season on the Main Southwest Miramichi since the early 1960's (Dalton, pers. comm.).

The timing of the run at Ten Mile during the project was similar to that during the 1970's (Madden 1979). Examination of daily trap records (Appendix IIa-g)) indicate that the barrier system operated sufficiently early in the season to protect the earliest arrivals which are large salmon.

The timing of the salmon runs at the barriers on the Miramichi during the projects cannot be compared with historical records because these are nonexistent at, or in proximity to, the barriers. However, information on the salmon runs provided by local anglers indicate the first fish arrive by late May or early June. The annual commencement of the operation of the barriers at Frying Pan and Bridge pools is approximately three weeks late to count the earliest arrivals. The first arrivals are large salmon, which representd the age class at which current conservation efforts are directed and it is important to accurately monitor the benefits of those efforts.

At the Ten Mile and Frying Pan pool barriers

there does not appear to be a measurable increase in the proportion of large salmon relative to grilse even though there has been greater escapement of large fish due to conservation efforts since 1984. The apparent reason for the immeasurability is the concurrent increase in the number of grilse.

Survival to Spawning

There is no evidence to suggest that salmon in any of the barrier pools were overcrowded. Mortality attributed to disease was negligible at Frying Pan and Bridge pools and only 3.3% of the total run at Ten Mile (Tables 9 and 10). Mortality due to furunculosis in the Restigouche system was not restricted to Ten Mile Pool. From 1979 to 1986, mortalities caused by furunculosis were recorded also on the Main Restigouche River and all major tributaries. The trend in the number of mortalities attributable to furunculosis at Ten Mile since 1979 is consistent with that reported for the Restigouche system (Appendix IV). The low mortality rate for salmon while detained in barrier pools for three to four months, despite the incidence of a virulent disease such as furunculosis in one of them, is evidence that the strategy has merit.

Concern was raised in the proposal stage of the

projects regarding the number of salmon that could be contained in the holding pools without overstressing them. One has only to read the historical commercial salmon harvest records (Dunfield, 1986) that indicate that two hundred years ago the headwater pools of the Miramichi and Restigouche tributaries may have contained five to ten fold the number of salmon they held in 1986.

The Northwest Upsalquitch River appears to have a chronic poaching problem upstream from the barrier upon release of salmon prior to spawning, but the concerted effort by DNRE and DFO enforcement personnel has kept the illegal harvest to less than 16% of the run.

Earlier, we stated that poachers harvested at least 61% and 48% of the early run salmon on the Closed Water of the Northwest Upsalquitch in 1975 and 1978, respectively, but during the project we learned that these figures were conservative. At Ten Mile Pool in 1979 and 1980 it was determined that, between July 24 and August 28, which closely approximates the dates of the surveys in 1975 and 1978, the run increased by 79.6% and 77.1% respectively, with a mean of 78.0%. Using this datum, a recalculation of the proportion of the runs removed by poaching indicates that 78.3% and 71.0% of the early run salmon were taken illegally

in 1975 and 1978, respectively (Madden, unpubl.).

The mean survival rate of 80% of fish enumerated at Ten Mile Pool is a complete reversal of the situation prior to the project. The lowest survival rate during the project (43%) was recorded in 1981 when a private warden organization manned the Pool on a trial basis. In that year, an unauthorized release of fish resulted in intensive poaching upstream (Madden, 1981).

The increases in the number of redds, both upstream and downstream from Ten Mile Pool, were partly due to restrictive angling and commercial regulations imposed in 1984, but the increase upstream was twofold that downstream which we believe to be attributable to the barrier project.

The area upstream from Ten Mile Pool contains only 3.3% of the total amount of habitat accessible to salmon in the entire Restigouche drainage, but in 1986, it contained 18.6% of the spawners (Appendix V).

There appears to be a positive relationship between the number of large salmon arriving at the Ten Mile and Bridge pool fish traps and the number of redds. The relationship on the Dungarvon River is not as well defined where upstream migration of salmon released from Frying Pan Pool was impeded in some years by low water flows and/or beaver dams, and because a

relatively small portion of the available spawning area was surveyed. In years with extremely low fall water levels, such as 1985, salmon held at Frying Pan Pool did not ascend as far upstream upon release as previously observed. This was evidenced by the high concentration of redds between Herb Pond and Frying Pan Pool. This may be significant if barriers are used on rivers or sections of rivers where upstream migration of fish is dependent upon adequate water levels to negotiate obstructions.

Evaluation of the Fence Structures

The advantages of the conduit fence design include ease of cleaning and handling, durability and minimal injury to fish. The major disadvantage is capital cost. Although the vertical fence can be easily installed on gravel substrate, installation is more difficult on rock-rubble bottom and impossible on ledge substrate. When installed on gravel this type of fence design has a tendency to scour around the support posts and if scouring is extensive, the fence has a tendency to collapse. The tripod supported fences appear to provide much better support and can be installed on any substrate. The majority of breaches at Ten Mile Pool resulted from high water over or around the fence. The number of breaches

at Frying Pan Pool were minimal, while scouring was a routine problem associated with the fences at Bridge Pool. It appears the fence design and type of substrate should be factors in considering the placement of portable fences. Chain-link fences are relatively inexpensive, but much more difficult and time consuming to clean. There is also the potential for small grilse to gill in chain-link fences.

Additional Benefits

In addition to their primary function of fish protection, barrier projects also allow for the collection of data on the magnitude and timing of the run, population structure, egg deposition, egg and broodstock collection, disease, movement and survival rates including hook and release studies. This additional data will assist in the establishment of total allowable catch of sea-run Atlantic salmon. Conventional enforcement methods would not provide this type of data.

Costs

The costs associated with barrier projects are minimal in comparison to the costs of an equal degree of protection of the salmon resource by conventional methods. It would be virtually impossible to ensure

the same degree of protection by conventional methods.

Although the barrier project is cost effective, a significant financial commitment is required to operate them.

CONCLUSION

The barrier pool strategy has proven to be an effective and practical enforcement technique contributing to increased spawning escapement of Atlantic salmon in three river systems in New Brunswick.

RECOMMENDATIONS

1. The three barrier pool projects should be continued until optimum spawning escapement has been achieved for at least one life cycle of the salmon. Even then, consideration should be given to maintaining the operations as an effective enforcement technique.

2. The Dungarvon and North Branch barrier projects should be recognized as long-term departmental programs and funding should be established within regional budgets as has occurred with the Upsalquitch project.

3. The three barrier pool projects should operate from June 1 to November 1 annually, river conditions permitting.

4. The establishment of barrier projects should be considered on other river systems where salmon

populations are below optimum spawning escapement due to illegal in-river harvest and where conventional enforcement methods are ineffective.

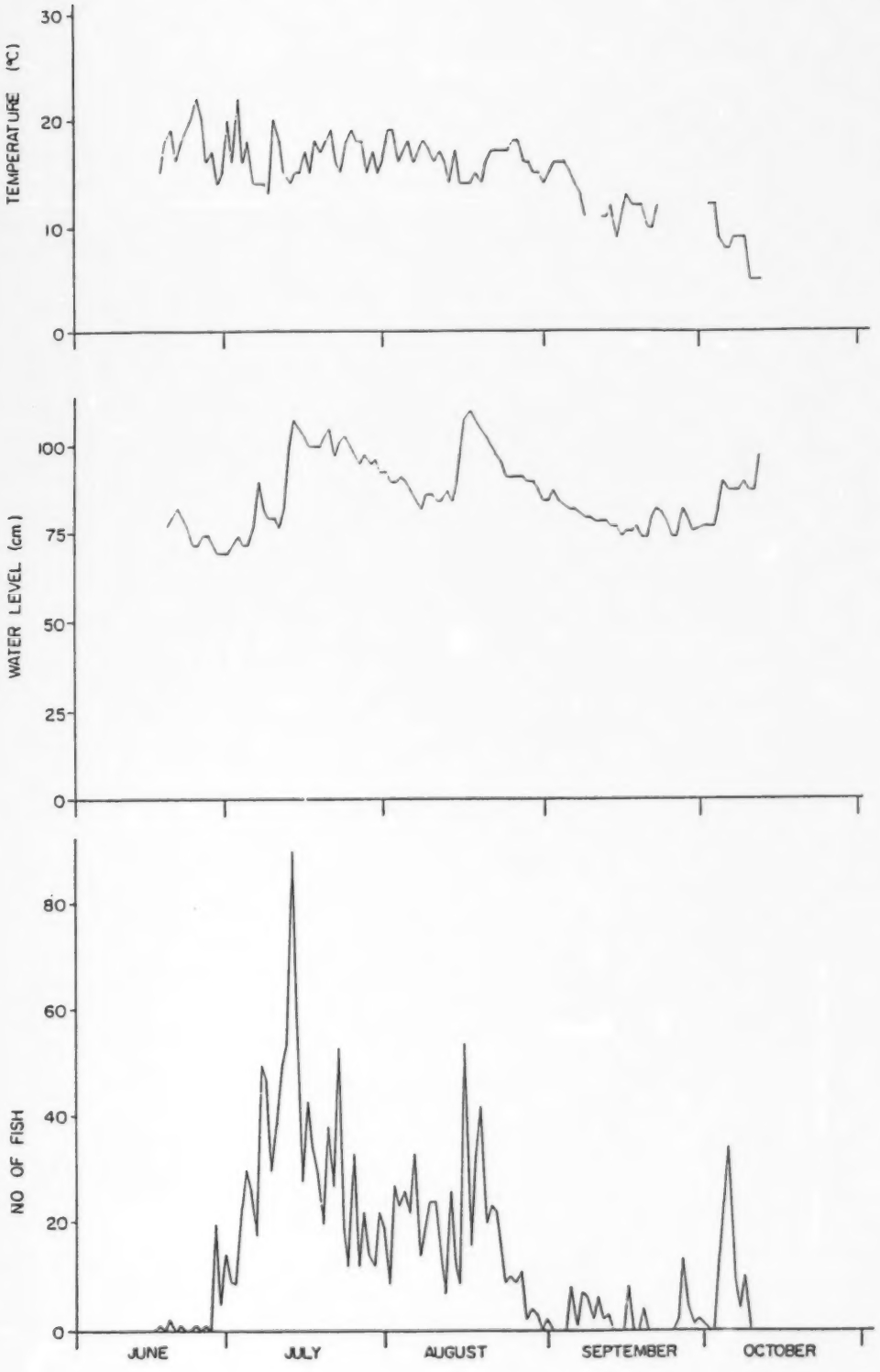
5. Data from the counting fences should continue to be used as indices of salmon populations, thereby providing information required to establish allowable harvest rates.

6. The literature on required egg deposition should be reviewed and estimates made on the number of fish required for optimum spawning upstream from the barrier sites. Consideration should be given to the release of fish from the barrier sites that are surplus to these spawning requirements.

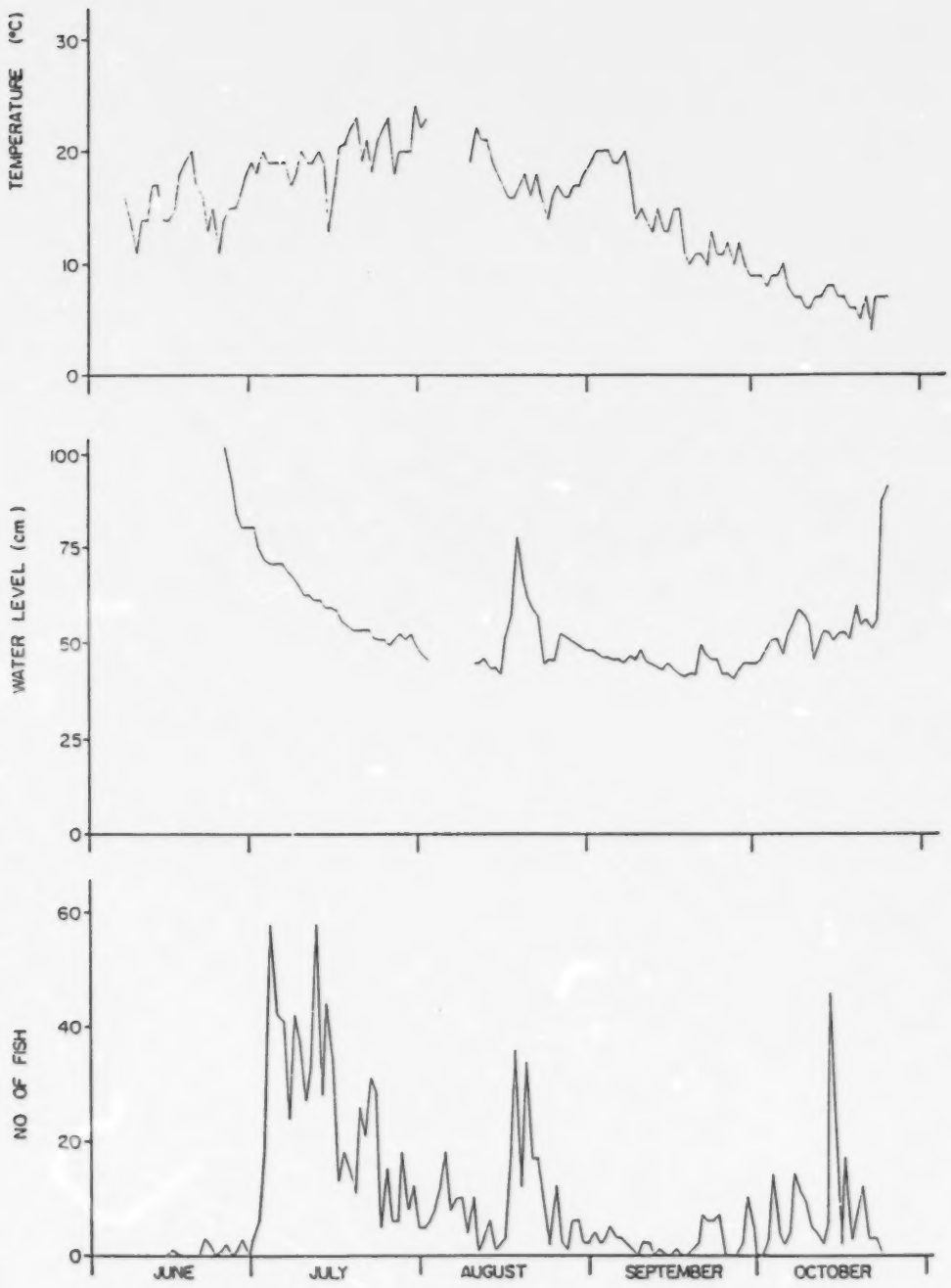
APPENDIX I. Impact of illegal fishing on Atlantic salmon stocks in the closed waters of the Northwest Upsalquitch River, N.B., in 1975 and 1978.

Year	No. grilse and large salmon counted by the same DNRE observer on all four dates	% Diff.
1975	344 (July 24) 133 (Aug. 29)	-61[a]
1978	138 (July 24) 72 (Sept. 19)	-48[a]

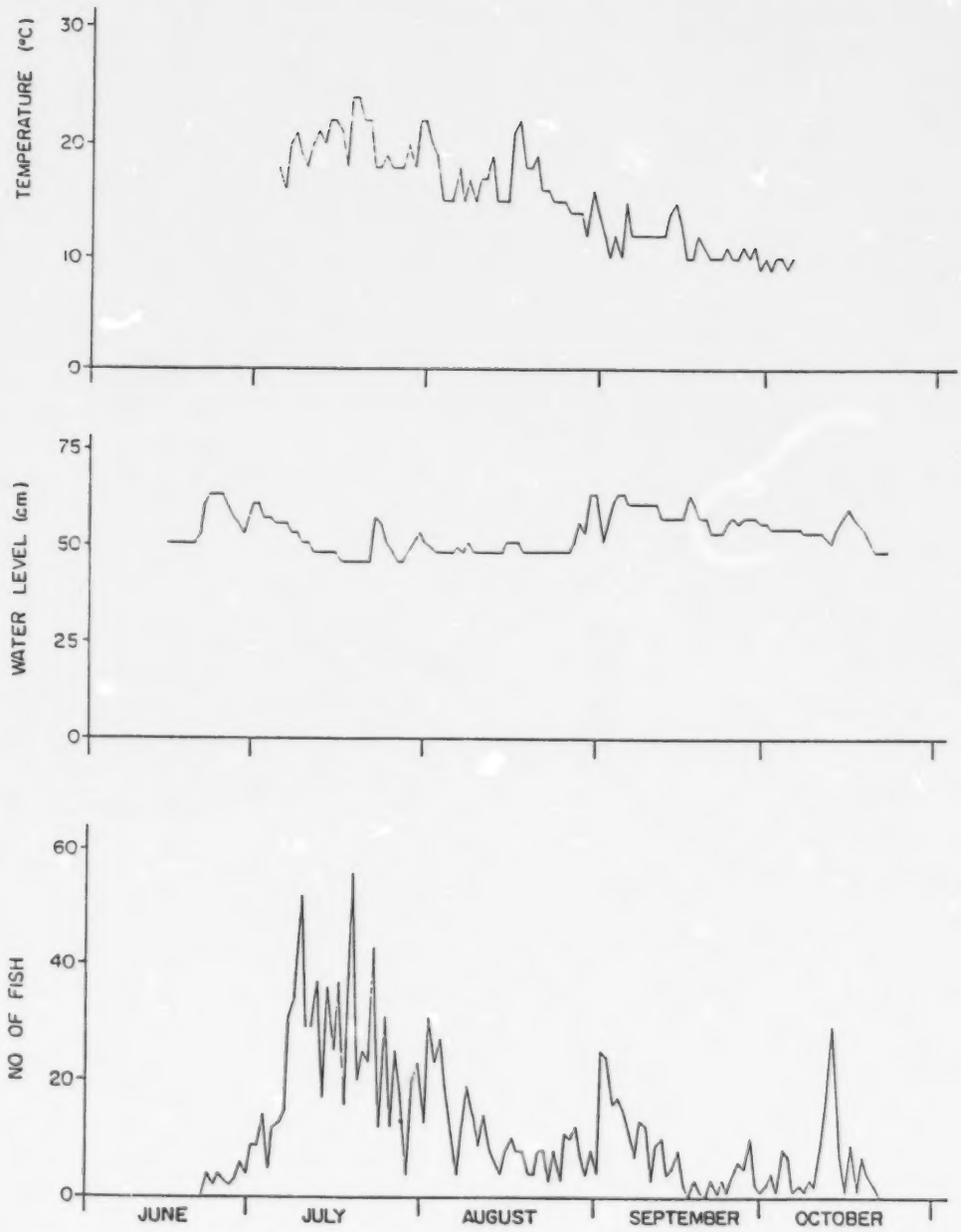
a - Minimums because (1) fish enter the stretch steadily from July 24 to late August, and (2) evidence of poaching that occurred prior to the counts on July 24 was observed in both years. In 1978, a federal officer saw an estimated 200 salmon in 12 Mile Pool one day prior to the first count by the DNRE observer. The latter counted only 8 fish there July 24 and noted that the pool had been netted.



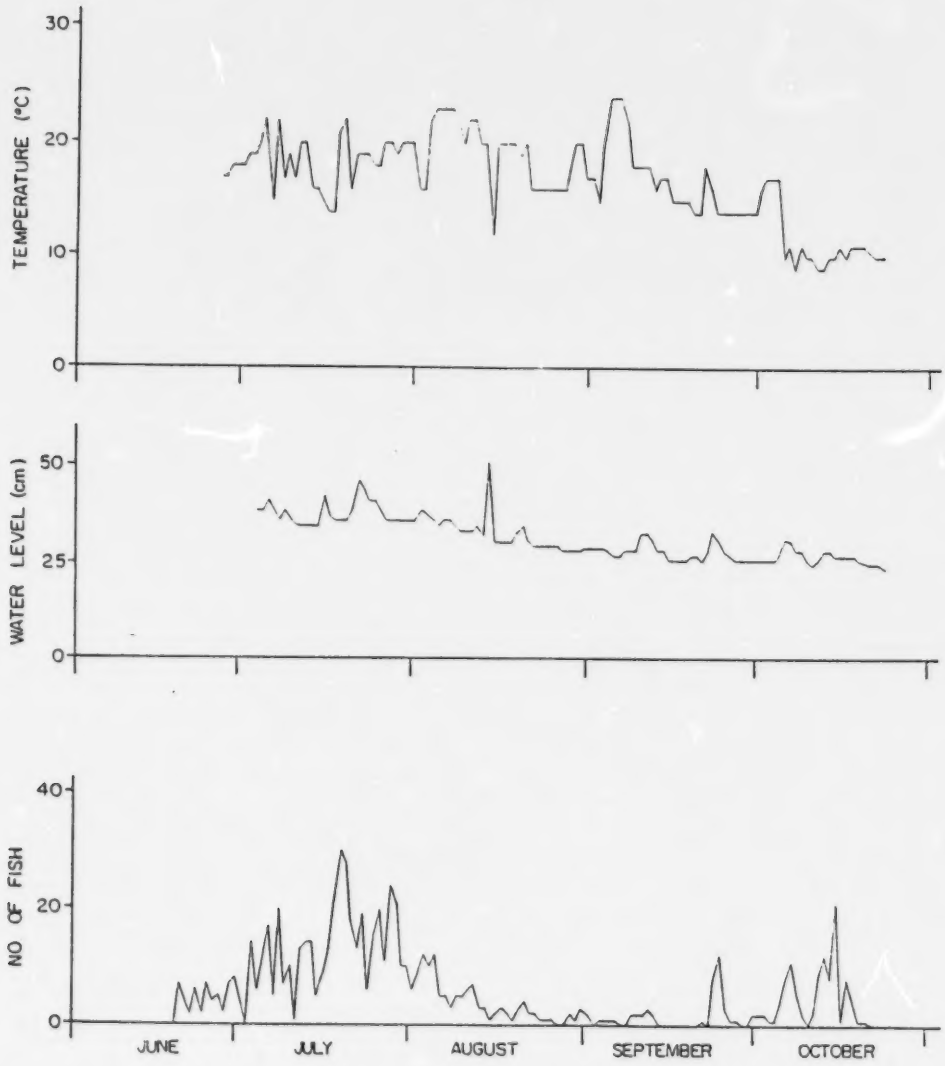
APPENDIX IIa. Number of Atlantic salmon, water temperature and level recorded daily, Northwest Upsalquitch River, 1980.



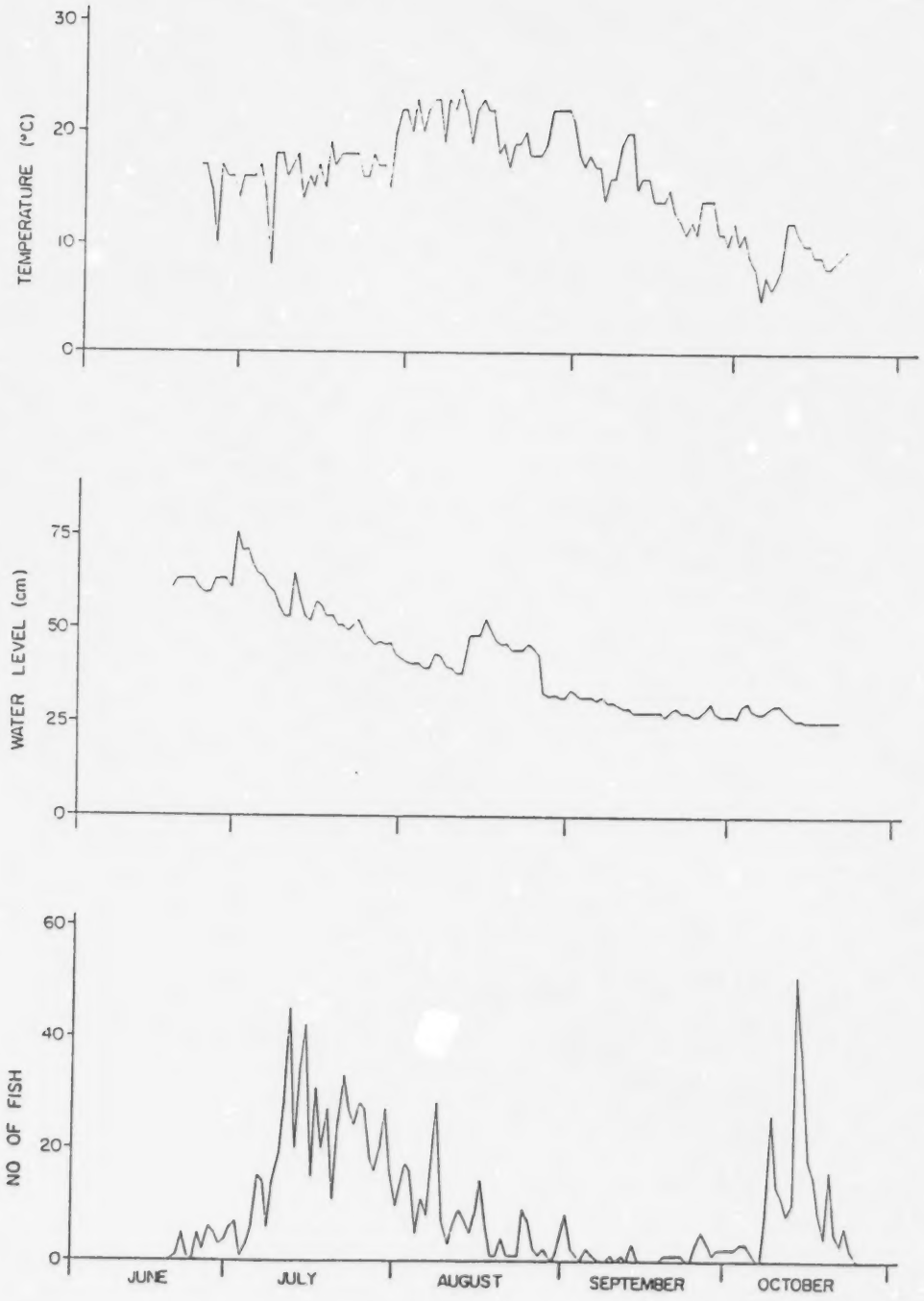
APPENDIX IIb. Number of Atlantic salmon, water temperature and level recorded daily, Northwest Upsalquitch River, 1981.



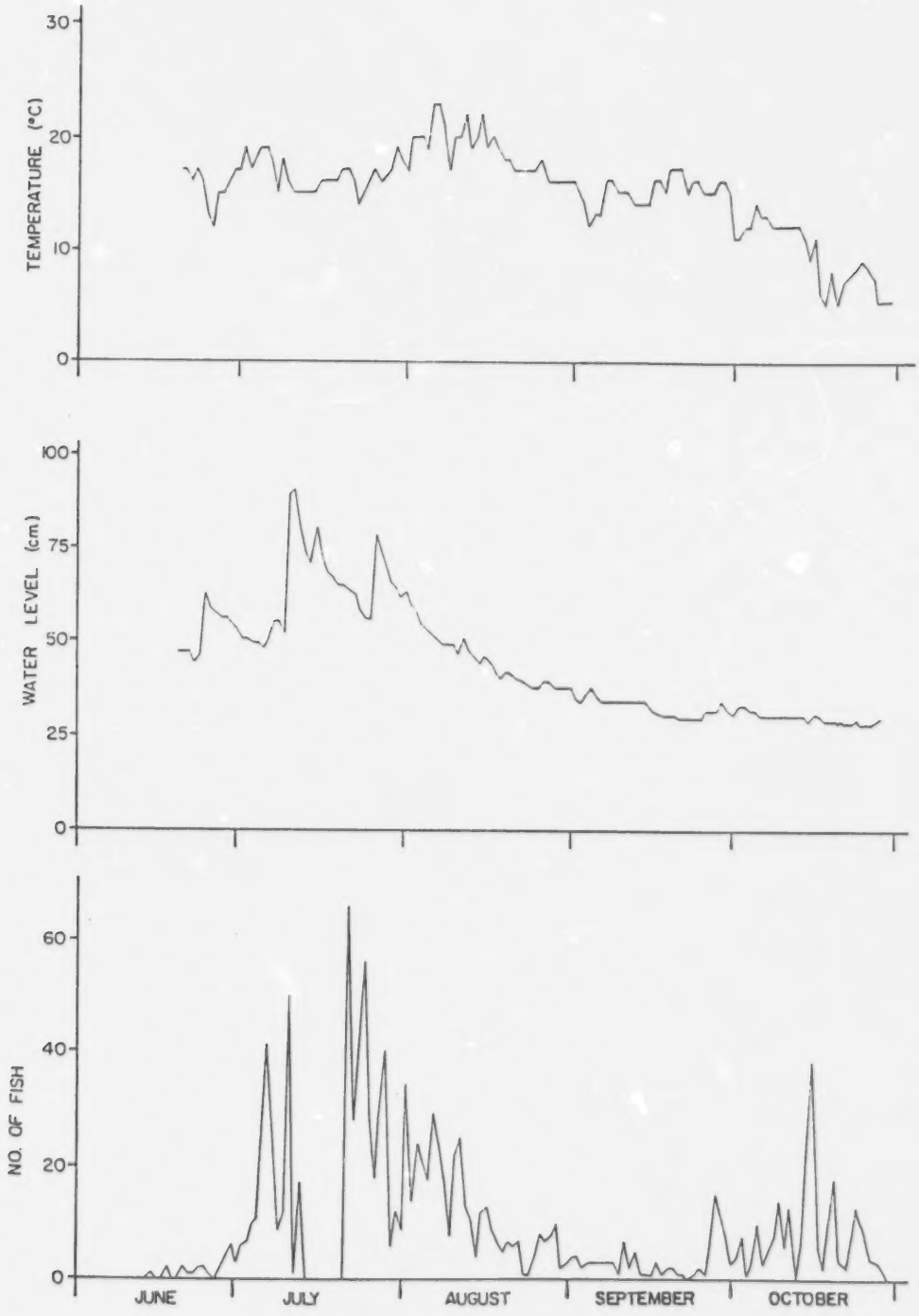
APPENDIX IIc. Number of Atlantic salmon, water temperature and level recorded daily, Northwest Upsalquitch River, 1982.



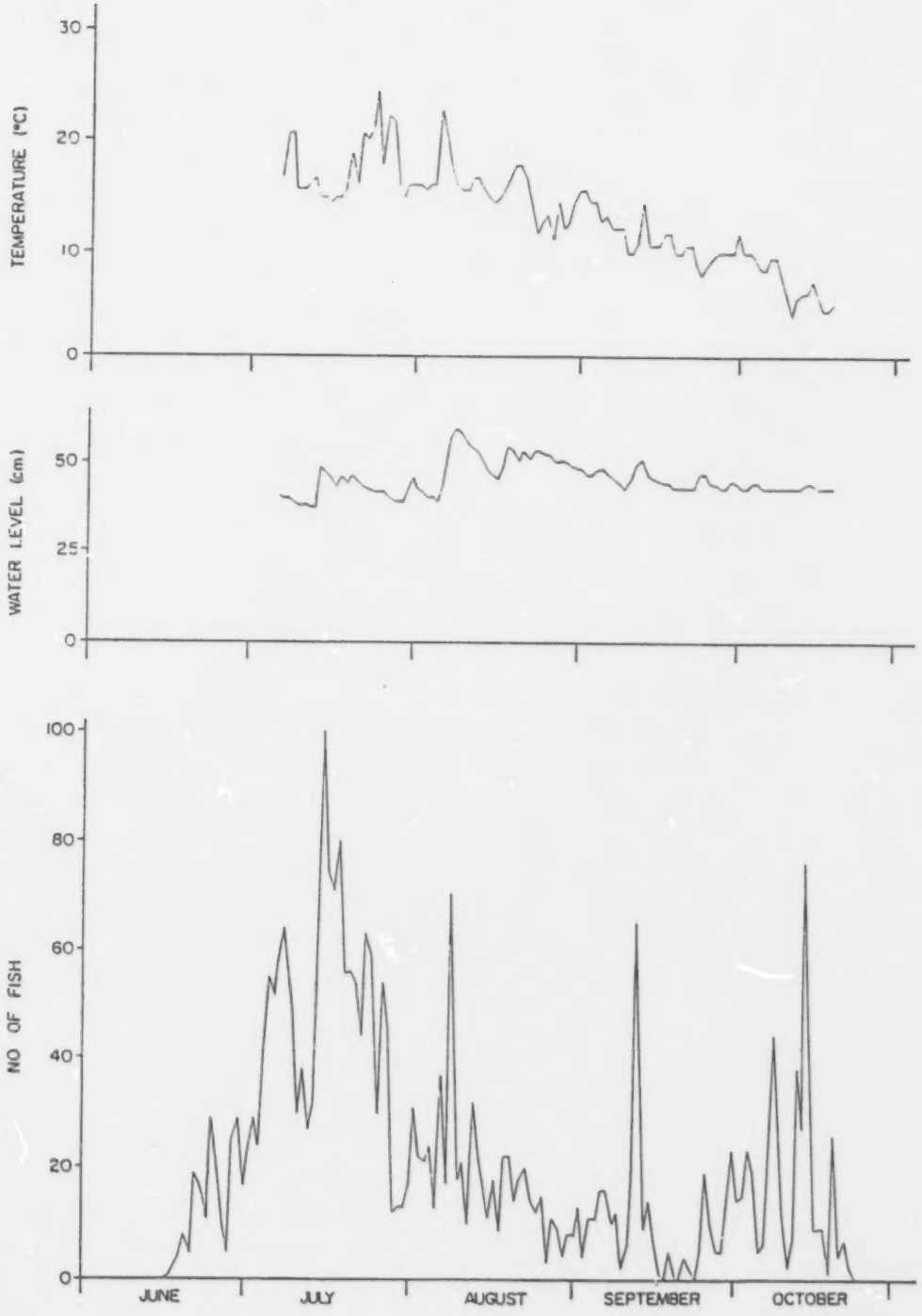
APPENDIX IId. Number of Atlantic salmon, water temperature and level recorded daily, Northwest Upsalquitch River, 1983.



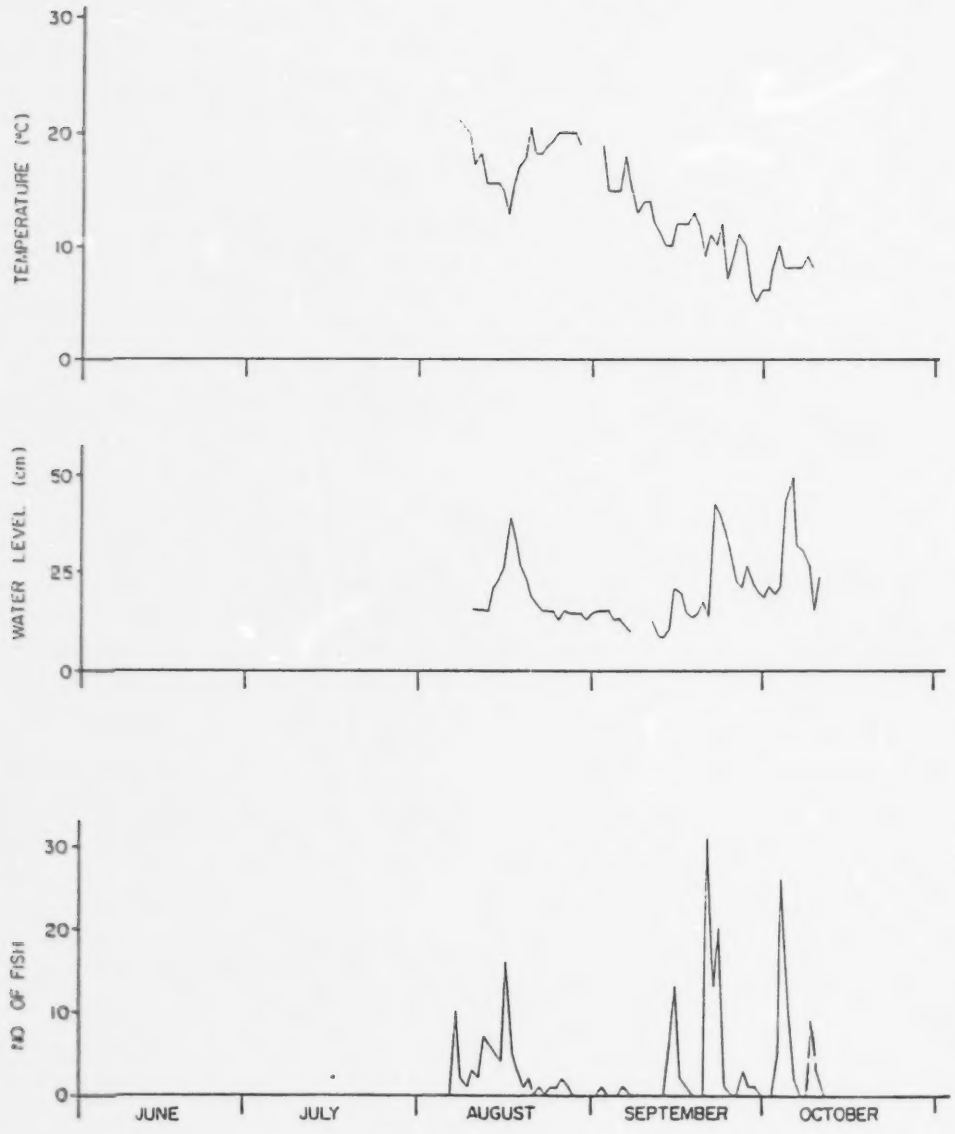
APPENDIX IIe. Number of Atlantic salmon, water temperature and level recorded daily, Northwest Upsalquitch River, 1984.



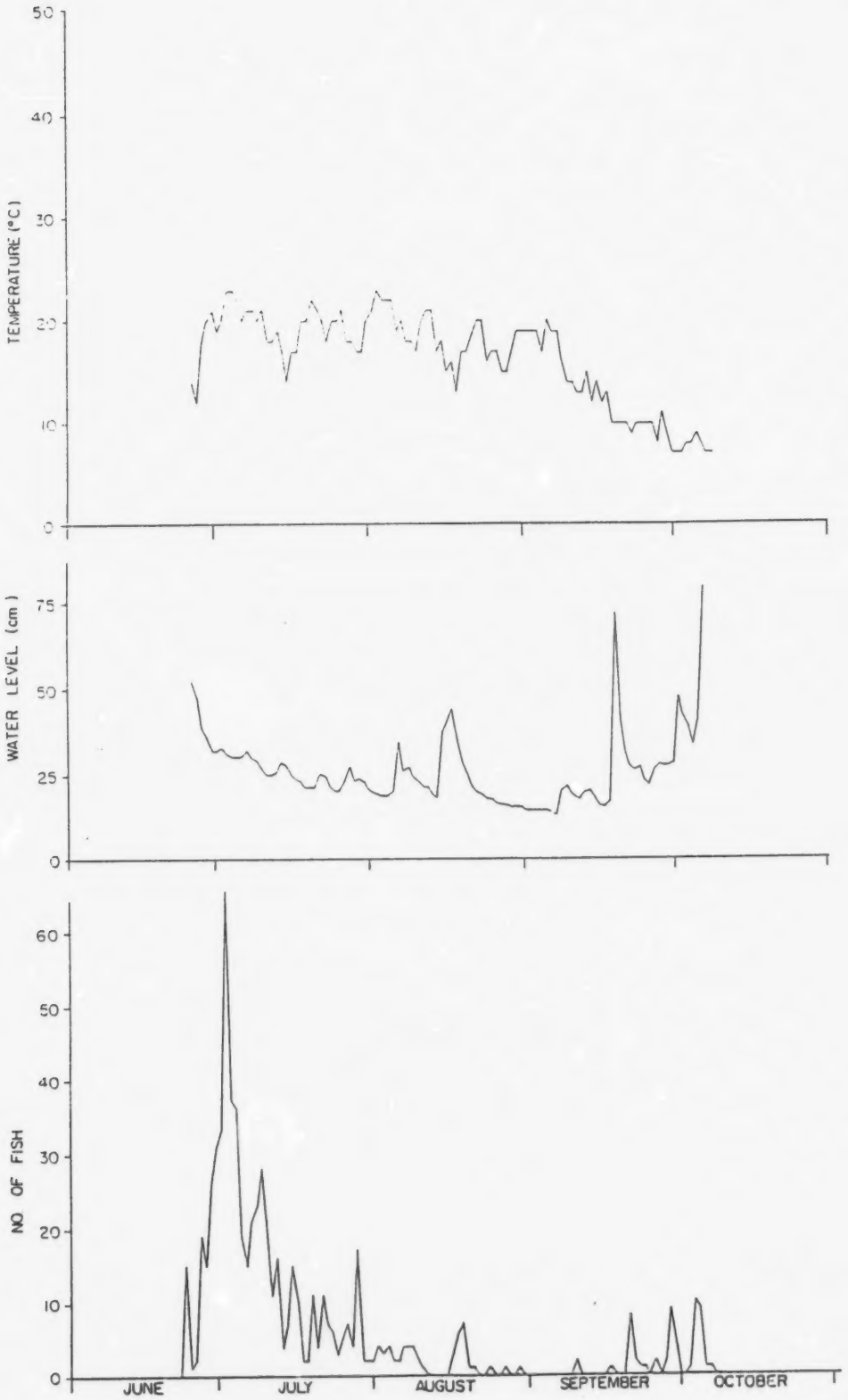
APPENDIX IIf. Number of Atlantic salmon, water temperature and level recorded daily, Northwest Upsalquitch River, 1985.



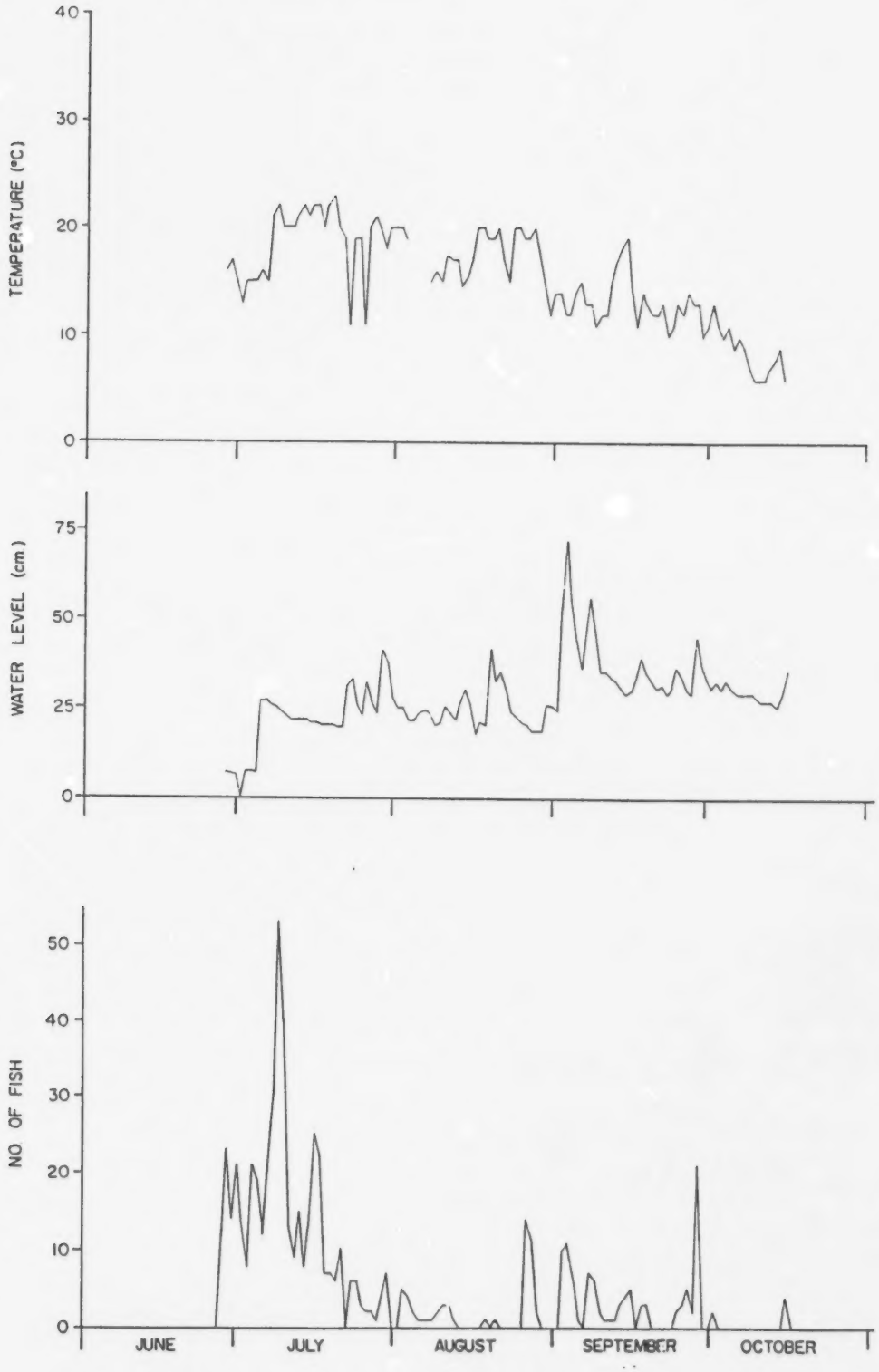
APPENDIX IIg. Number of Atlantic salmon, water temperature and level recorded daily, Northwest Upsalquitch River, 1986.



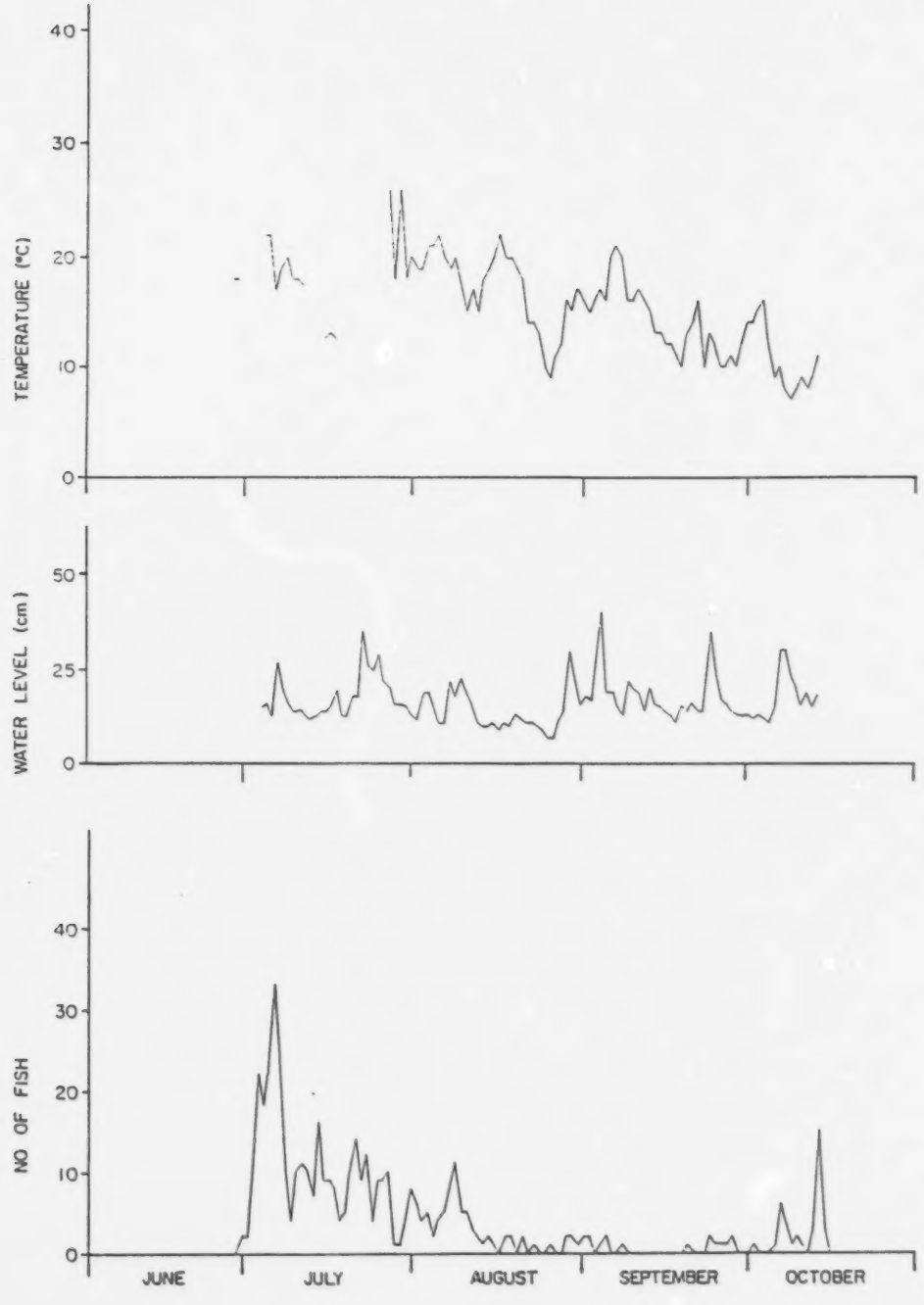
APPENDIX IIh. Number of Atlantic salmon, water temperature and level recorded daily, Dungarvon River, 1980.



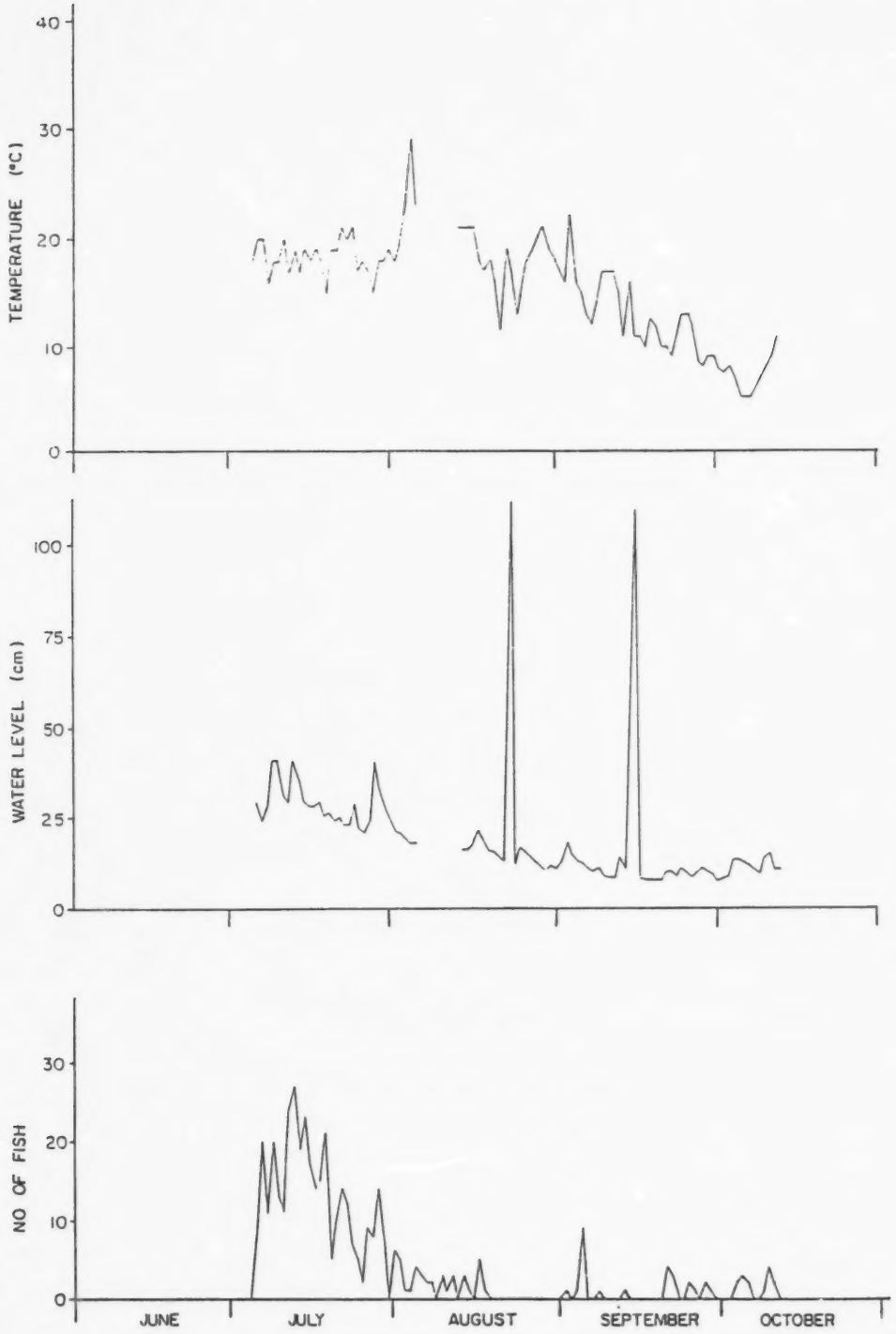
APPENDIX IIi. Number of Atlantic salmon, water temperature and level recorded daily, Dungarvon River. 1981.



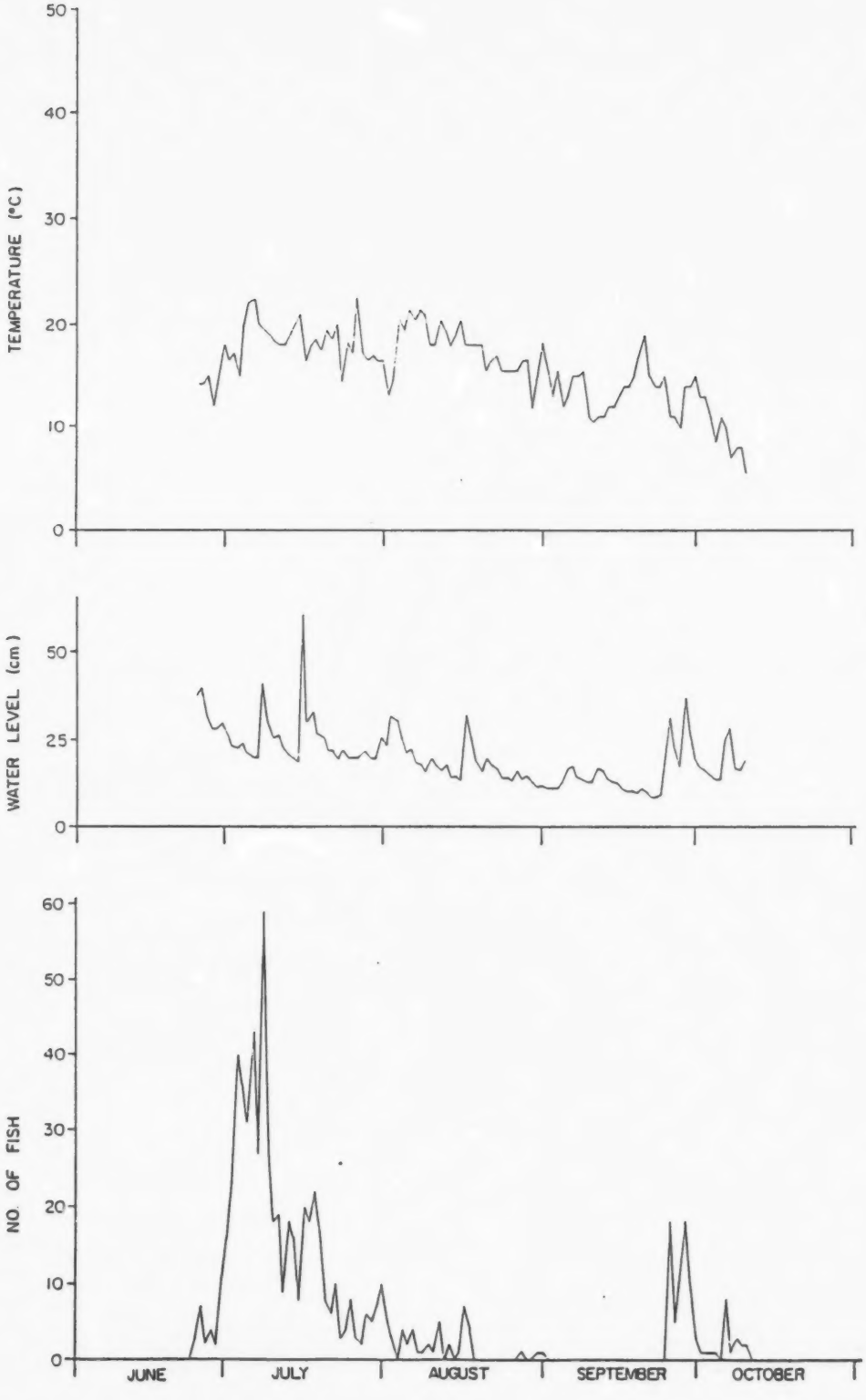
APPENDIX IIj. Number of Atlantic salmon, water temperature and level recorded daily, Dungarvon River, 1982.



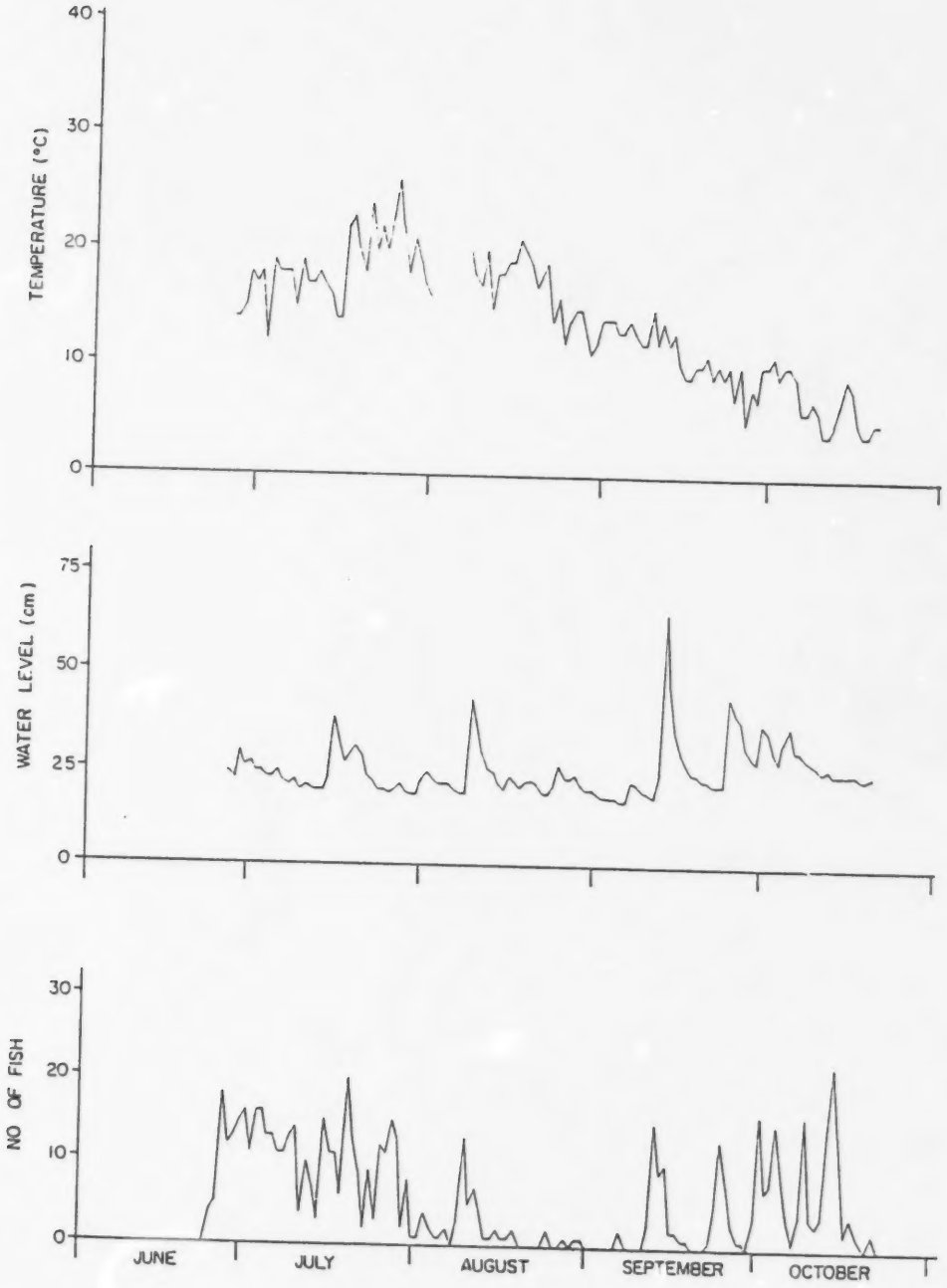
APPENDIX IIk. Number of Atlantic salmon, water temperature and level recorded daily, Dungarvon River, 1983.



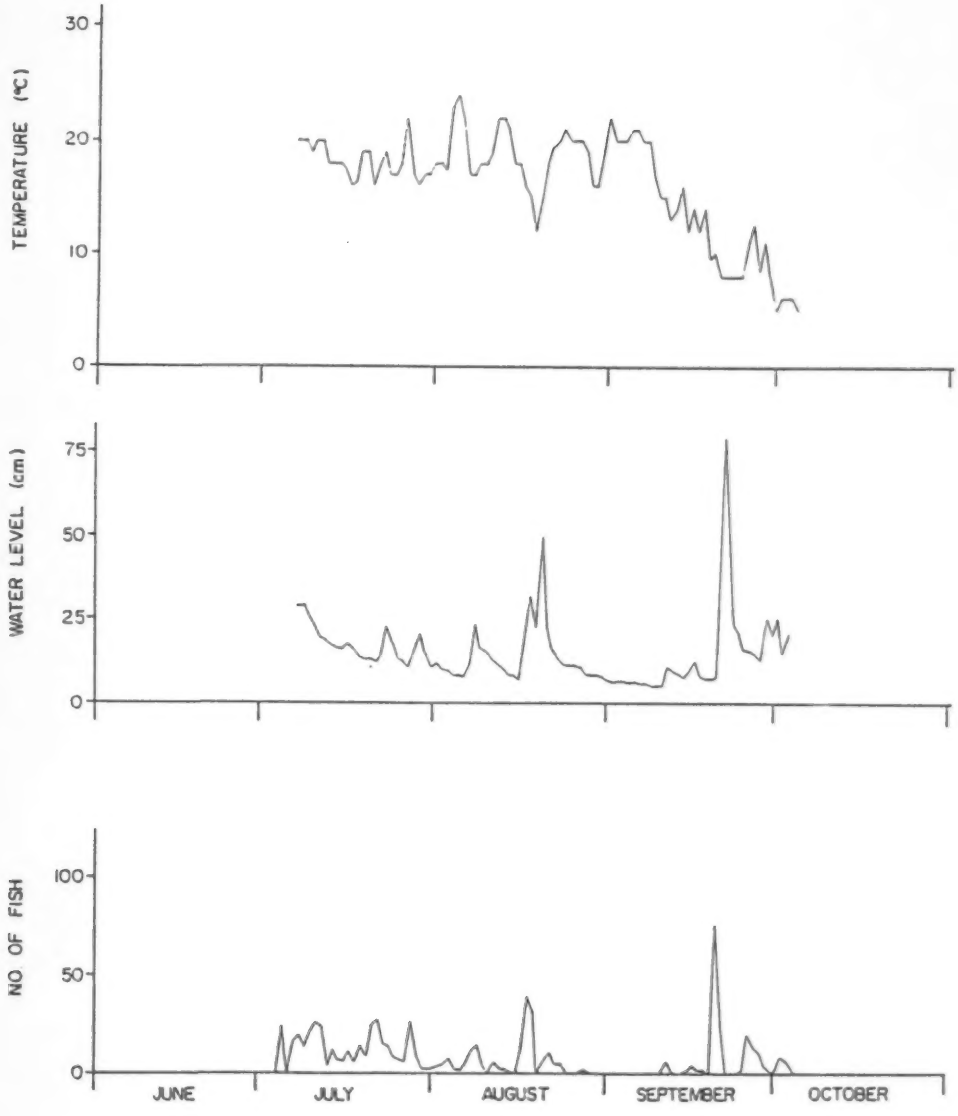
APPENDIX III. Number of Atlantic salmon, water temperature and level recorded daily, Dungarvon River, 1984.



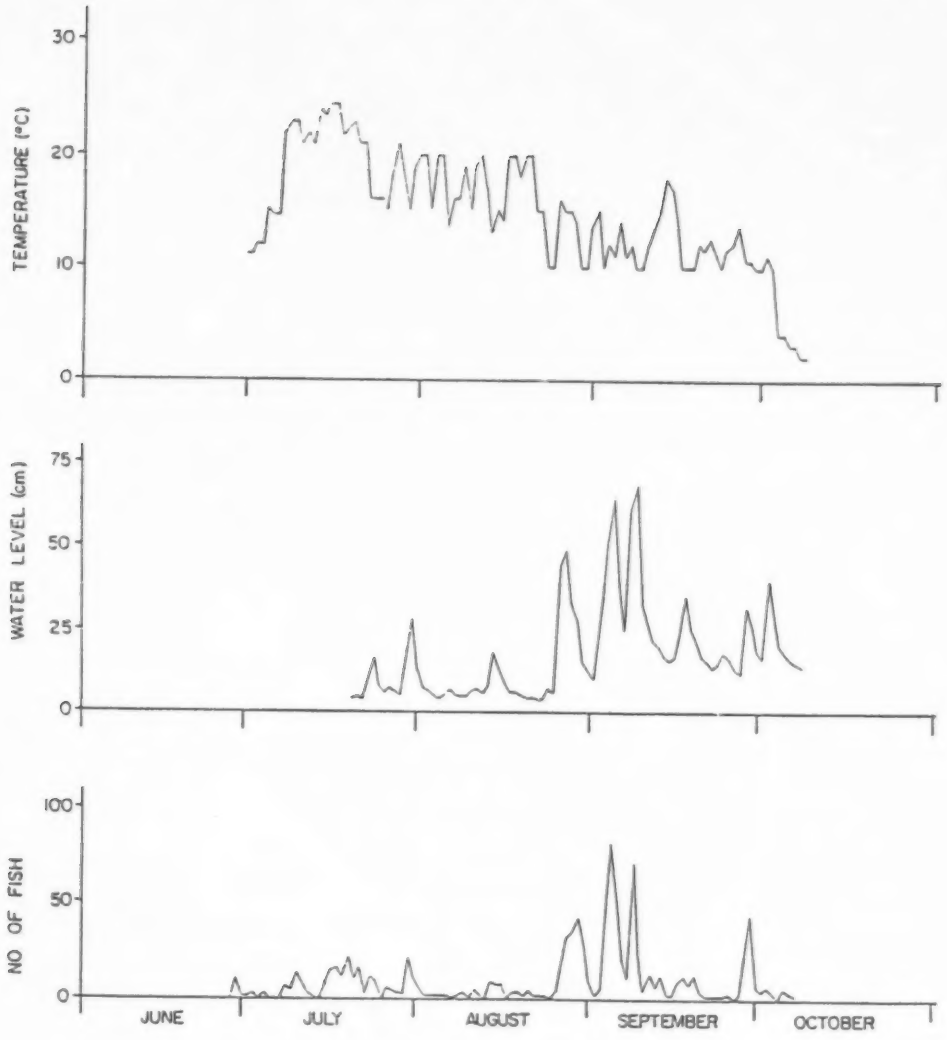
APPENDIX IIm. Number of Atlantic salmon, water temperature and level recorded daily, Dungarvon River, 1985.



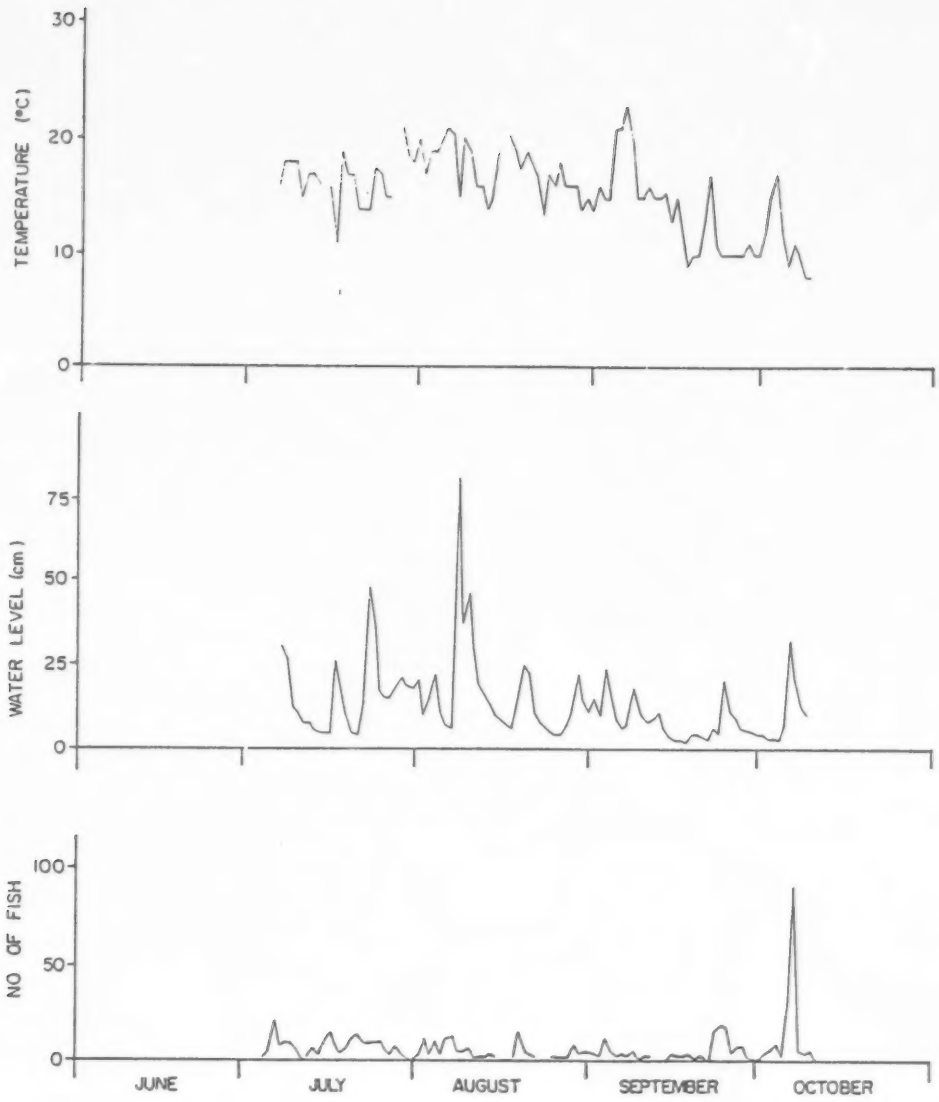
APPENDIX IIn. Number of Atlantic salmon, water temperature and level recorded daily, Dungarvon River, 1986.



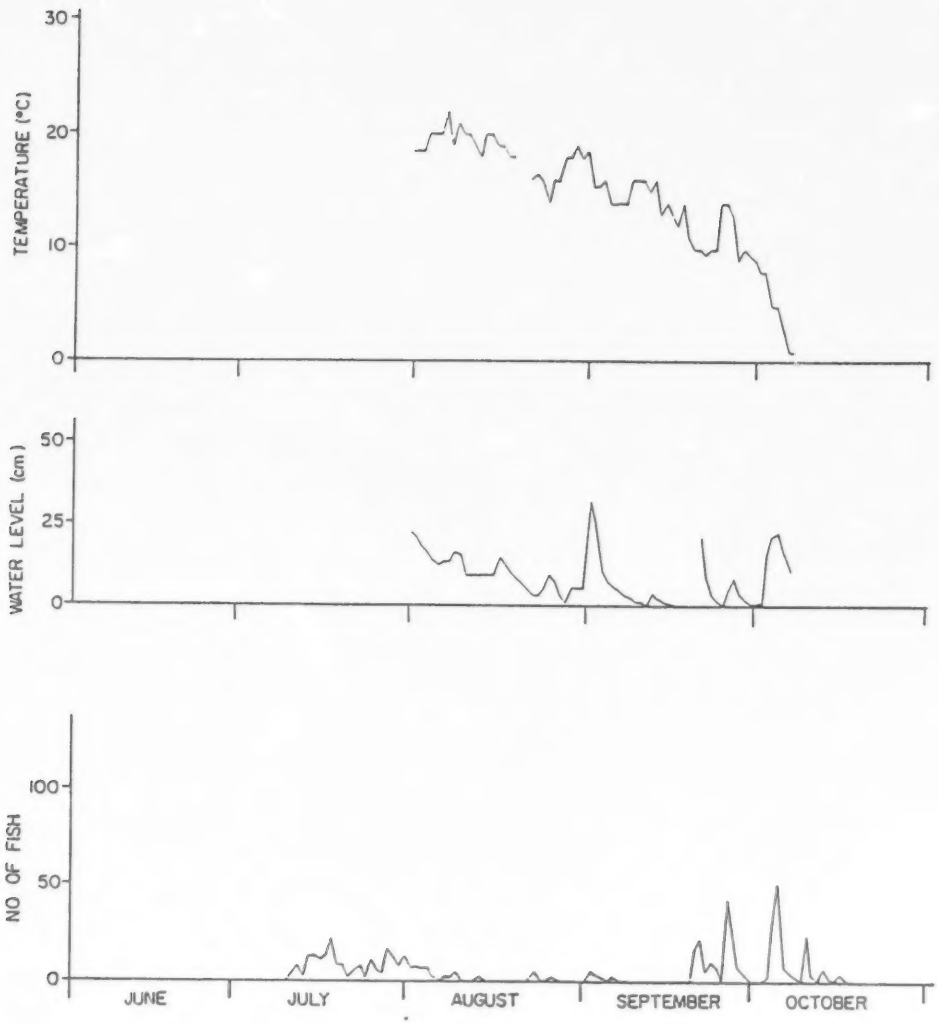
APPENDIX II0. Number of Atlantic salmon, water temperature and level recorded daily, North Branch of the Main Southwest Miramichi River, 1981.



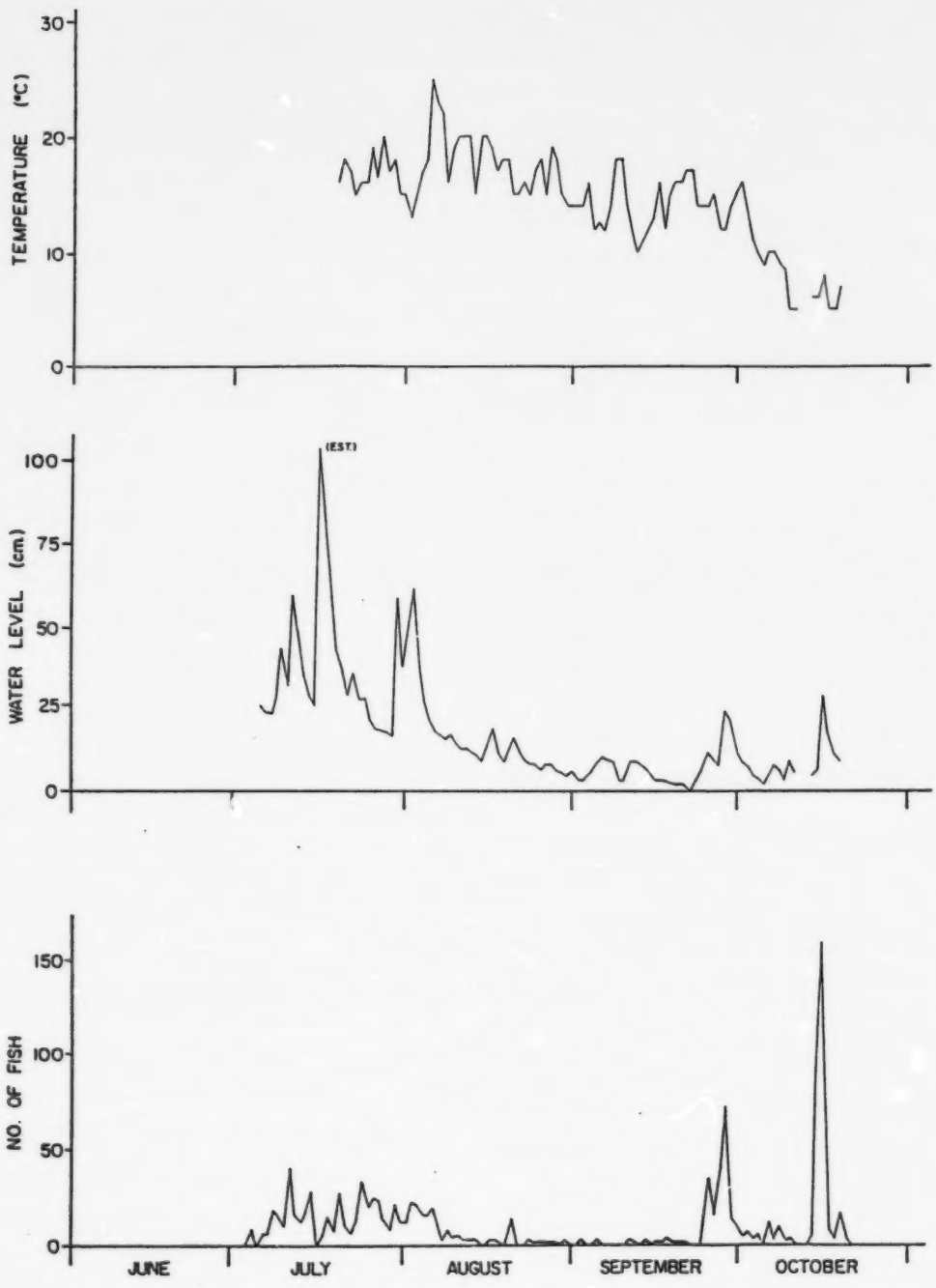
APPENDIX IIp. Number of Atlantic salmon, wqter temperature and level recorded daily, North Branch of the Main Southwest Miramichi River, 1982.



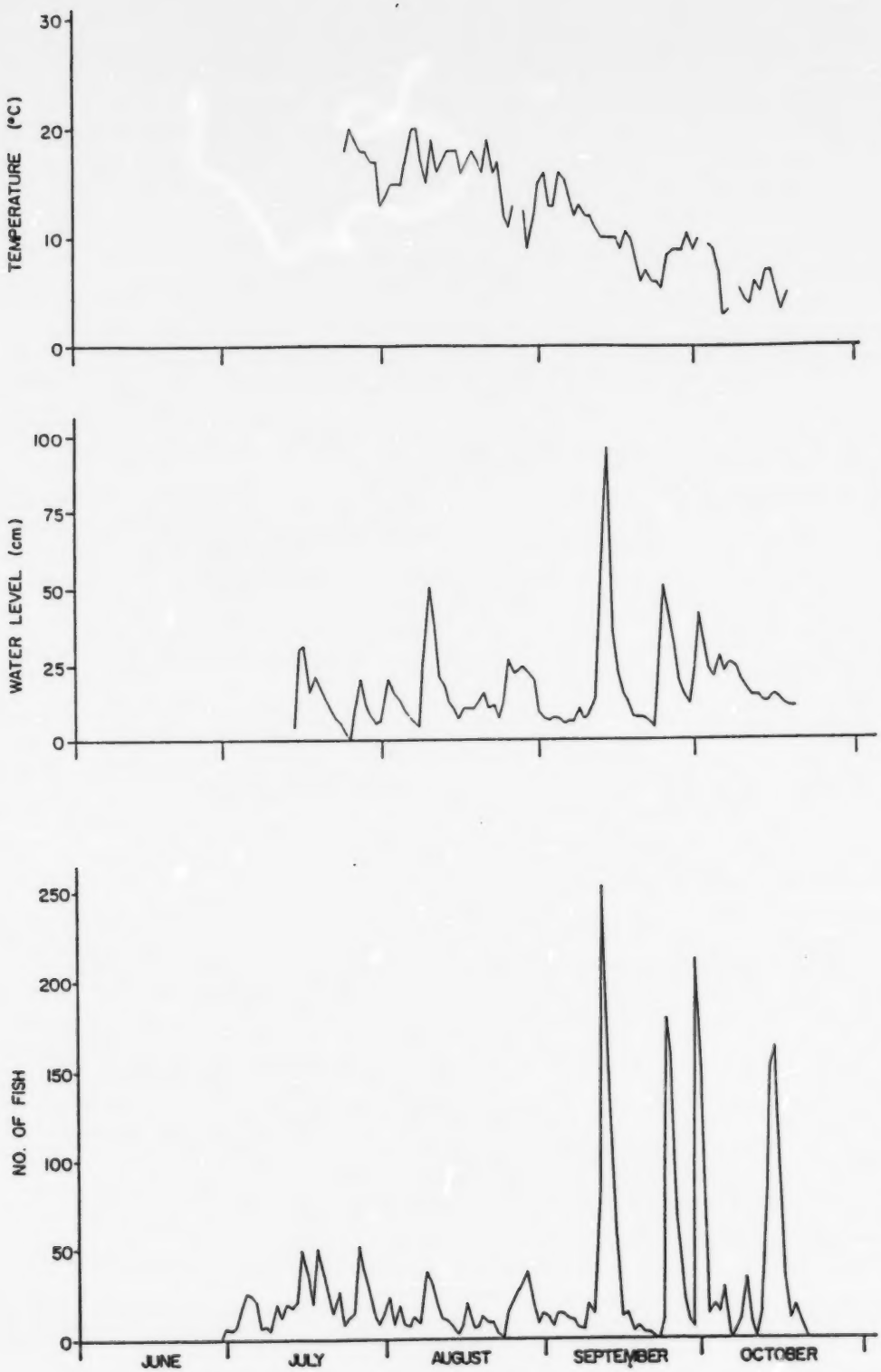
APPENDIX IIq. Number of Atlantic salmon, water temperature and level recorded daily, North Branch of the Main Southwest Miramichi River, 1983.



APPENDIX IIr. Number of Atlantic salmon, water temperature and level recorded daily, North Branch of the Main Southwest Miramichi River, 1984.



APPENDIX IIs. Number of Atlantic salmon, water temperature and level recorded daily, North Branch of the Main Southwest Miramichi, 1985.



APPENDIX IIt. Number of Atlantic salmon, water temperature and level recorded daily, North Branch of the Main Southwest Miramichi River, 1986.

APPENDIX III. Numbers of Atlantic salmon and grilse counted at traps on the Miramichi drainage, 1984-1986.

Trap Site	1984		1985		1986		% Difference Salmon		% Difference Grilse	
	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	1984-85	1985-86	1984-85	1985-86
Frying Pan Pool Dungarvon River (DNRE)	93	315	162	536	174	501	+74.2	+7.4	+70.1	-6.5
Bridge Pool North Br. Main S.W. Miramichi (DNRE)	297	230	604	492	1138	2072	+103.4	+88.4	+113.9	+321.1
Millbank Miramichi Estuary (DFO)'	339	1010	311	912	469	1763	-8.2	+50.8	-9.7	+93.3
Southwest Miramichi Estuary at Wilson's Pt. (DFO)'	--	--	486	848	585	1519	--	+20.4	--	+79.1
Northwest Miramichi Estuary at Wilson's Pt. (DFO)'	--	--	204	695	264	832	--	+29.4	--	+19.7

' Source - Randall (pers. comm.)

APPENDIX IV. Estimated number of Atlantic salmon mortalities attributable to furunculosis in the Restigouche River system and general remarks, 1975-1986, based on reports by DNRE, M.L.C.P. and Restigouche Riparian wardens and Crown Reserve anglers.

Year	Grilse	Salmon	Total	Remarks
1975	0	500	500	Found 380 by July 16; lowest water in 30-40 years.
1976	0	300	300	Normal water levels.
1977	50	250	300	High water all summer.
1978	50	450	500	Lowest water level reported in 60 years.
1979	500	500	1000	Lowest water level reported for June-August. Dramatic decline in 2 and 3 SW salmon.
1980	500	1500	2000	Extremely high water all summer. Largest 2 SW salmon run in 14 years.
1981	100	400	500	240 counted on July 31. Largest run of 3 sw salmon in 15 years.
1982	50	450	500	Dramatic decline in 2 SW salmon.
1983	75	225	300	Water level all summer lower than in 1979. Decline in 3 SW salmon; continued lack of 2 SW.
1984	50	200	250	Water level similar to that of 1983.
1985	15	45	60	
1986	30	90	120	Above normal water level; largest 1 SW and 2 SW salmon run in 19 years.

APPENDIX V. Distribution of Atlantic salmon habitat and spawners in the Restigouche River system, 1986'.

River System	Habitat		Spawners	
	Area(m^3)	% of Total	No.	% of Total
Little Main Restigouche	2,242,880	6.8	3782	25.7
Kedgwick	2,609,040	8.0	1257	8.5
Main Restigouche	14,803,840	45.1	2121	14.4
Patapedia	2,028,000	6.2	1039	7.0
Upsalquitch				
Upstream from Ten Mile Pool	1,096,640	3.3	2740	18.6
Remainder of Upsal. System	3,120,590			
Upsalq. Sub-total	4,217,230	12.8	5083	34.5
Matapedia	6,915,00	21.1	1450	9.8
Totals	32,815,990		14,732	

' Based on field surveys by DNRE and MLCP on 86% of the habitat accessible to salmon.